NASA SP-3044

A NUMERICAL LEAST-SQUARE METHOD FOR RESOLVING COMPLEX PULSE HEIGHT SPECTRA

TROMBKA and SCHMADEBECK

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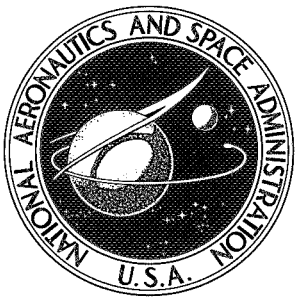

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A NUMERICAL LEAST-SQUARE METHOD FOR RESOLVING COMPLEX PULSE HEIGHT SPECTRA

By J. I. Trombka and R. L. Schmadebeck

Goddard Space Flight Center

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PREFACE

Over the past number of years, the author has been attempting to develop a general technique for determining the differential energy spectrum from a measurement of the pulse height spectrum. A numerical least-square analysis method seems to be most applicable for this analysis. Analytic methods have been developed herein and have been successfully applied to problems in gamma-ray, X-ray, and α-particle spectroscopy. Bits and pieces of the technique have been published over the years by the author, and at last the technique has been completed. In this publication an attempt will be made to bring this information together to form a complete picture of the background and application of the analytic method.

A NUMERICAL LEAST-SQUARE METHOD FOR RESOLVING COMPLEX PULSE HEIGHT SPECTRA

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With the development of extremely precise multichannel analyzers over the past years, a great interest has developed in the precise determination of differential energy spectra from measurement of the pulse height spectrum. Important applications of this technique can be found in gamma-ray spectroscopy for work in decay scheme determination and activation analysis, in X-ray spectroscopy for work in so-called nondispersive analyses, and in charged-particle spectroscopy for work in alpha-particle scattering and its application to geochemical analysis (References 1 through 9).

The basic problem involved in the spectroscopic investigations just mentioned is the determination of the "actual" incident differential energy spectrum from a measurement of the pulse height spectrum. The pulse height spectrum is in truth a measurement of the interaction of the incident flux with the detector. The measurement of the incident flux is further degraded by many other factors in the detection system itself. The approach taken in the methods described in References 1 through 9 is to try to infer the actual incident differential energy spectrum by correcting the measured pulse height spectrum for the instrumental smearing and geometric efficiency.

Both analytic transform and empirical matrix transform methods have been considered for performing this so-called unsmearing. The analytic transform methods have been plagued by two problems. First, it has been difficult to describe the pulse height functions in closed analytic form and, second, it has been difficult to obtain a unique solution (i.e., there are singularities appearing in the solution of the general problem). The empirical matrix inversion techniques seem to overcome these difficulties by, first, not requiring analytic description of the pulse height function, and, second, limiting the domain of solutions by imposing physical constraints. Thus it is in this context that this discussion will be presented, and the empirical matrix inversion method will be the technique of interest.

FORMULATION OF LEAST-SQUARE PRINCIPLE

The description will be restricted to problems in gamma-ray and X-ray spectroscopy. Consider characteristic pulse height spectra in gamma-ray spectroscopy using NaI (Tℓ) scintillation detectors. The pulse height spectra obtained when monoenergetic gamma rays are detected with a scintillation system are never lines but are of a shape determined by the energy of the gamma rays and the source detector configuration. The shapes of the monoenergetic height spectra are determined by such factors as the following:

1. The relative magnitude of the photoelectric Compton and pair-production cross sections.

2. The losses and statistical fluctuations that characterize the crystal, light collection, and photomultiplier system.

5. The presence of scattering material around the source and detector.

6. The presence of charged particles (i.e., electrons producing Bremsstrahlung and positrons producing annihilation radiation).

5. Coincidence effects.

There are other effects of somewhat secondary importance, but for a detailed description of these spectra refer to Reference 3. In the technique proposed, the standard spectra used

in the analysis can be either characteristic of the monoenergetic components or characteristic of certain elements (monoelemental components) which may be a sum of monoenergetic components. Consider the case for monoelemental components. Figures 1, 2, and 3 are pulse height

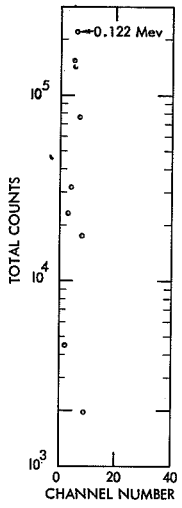


FIGURE 1.—Pulse height spectrum of Co^{57} 10 cm from 3×3-inch NaI (T*l*) crystal.

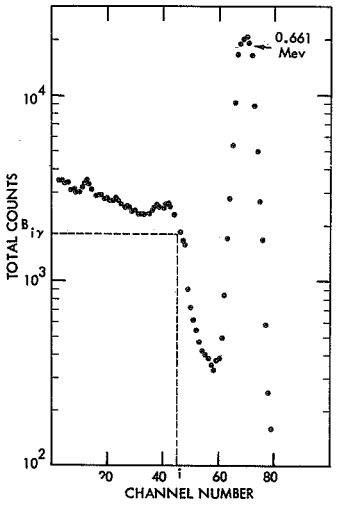


FIGURE 2.—Pulse height spectrum Cs^{137} 10 cm from a 3×3-inch NaI (T*l*) crystal.

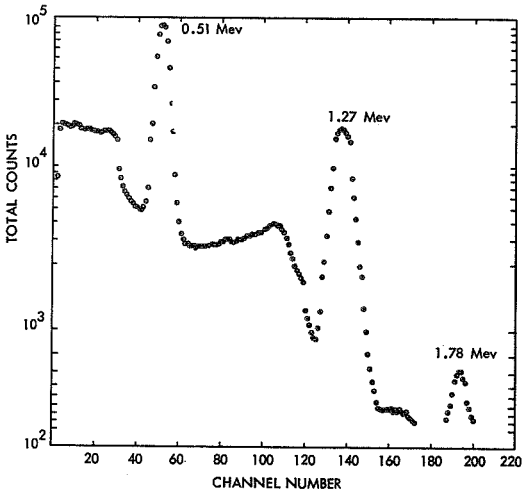


FIGURE 3.—Pulse height spectrum of Na^{22} 10 cm from a 3×3-inch NaI (T*l*) crystal.

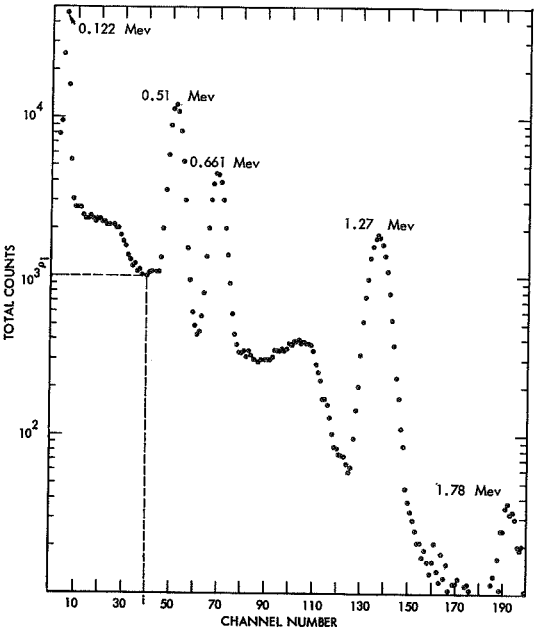


FIGURE 4.—Pulse height spectrum of a mixture of Co^{57}, Cs^{137}, and Na^{22} 10 cm from 3×3-inch NaI (T*l*) crystal.

spectra characteristic of Co^{57}, Cs^{137}, and Na^{22}. The counts in channel i for the γ^{th} component are $B_{i\gamma}$ (Figure 2). When a number of gamma rays are incident upon a NaI (T*l*) crystal, the measured pulse height spectrum is made up of a summation of the photopeaks, Compton continua, etc. Figure 4 shows the measured pulse height spectrum for a mixture of Co^{57}, Cs^{137}, and Na^{22}. If ρ_i is considered to be the total counts in channel i of the measured pulse height spectrum, then

$$\rho_i = \sum_{\gamma} \beta_{i\gamma}, \qquad (1)$$

using the monoelemental components. This expression can also be written as

$$\rho_i=\sum_\gamma \beta_\gamma A_{i\gamma}, \tag{2}$$

where $A_{i\gamma}$ is normalized as follows:

$$\beta_\gamma=\frac{B_{i\gamma}}{A_{i\gamma}}.$$

Because of the variance in the determination of ρ_i, $A_{i\gamma}$ cannot be determined simply from an inversion of Equation 2. Early attempts at using this simple inversion led to great confusion except for extremely simple cases. It is impossible to find the exact solution; therefore, an attempt is made to find the most probable values of $\beta_\gamma A_{i\gamma}$. The least-square criterion is used to determine these values; that is,

$$M=\sum_i \omega_i\left(\rho_i-\sum_\gamma \beta_\gamma A_{i\gamma}\right)^2 \tag{3}$$

where ω_i is the statistical weight for each channel i and

$$\omega_i\sim\frac{1}{\sigma_i^2}.$$

In formulating the linear least-square method, it is assumed that the pulse height scale does not vary between $A_{i\gamma}$ and ρ_i or among the various components of $A_{i\gamma}$ (i.e., there is no gain shift or zero drift) and, therefore, the minimum can be found by taking a partial derivative with respect to some relative intensity β_γ. The derivative is then set equal to zero:

$$\frac{\partial M}{\partial \beta_\gamma}=\sum_i \omega_i\left(\rho_i-\sum_\lambda \beta_\lambda A_{i\lambda}\right)A_{i\gamma}=0. \tag{4}$$

This can be written in matrix form (Reference 1) as

$$\tilde{A}\omega\rho-(\tilde{A}\omega A)\,\beta=0, \tag{5}$$

and solving for β gives

$$\beta=(\tilde{A}\omega A)^{-1}\,\tilde{A}\omega\rho, \tag{5a}$$

where A is an $m\times n$ matrix of the standard components, $\tilde{A}$ is the transpose of A, ω is a diagonal matrix of the weighting functions, ρ is a vector of the spectrum to be analyzed, and β is a vector of the relative intensities.

There are a number of questions which must be answered in determing the proper algorithm (i.e., the method of solution).

1. Is it possible to invert the matrix $(\tilde{A}\omega A)$ and obtain a unique solution?
2. Are the components of the A matrix linearly independent?
3. What is the nature of the ω matrix?
4. What is the effect of background and how does one compensate for background in the calculation?
5. How does one compensate for nonlinearities in the system?

CALCULATION OF ERRORS

Before proceeding with the method of solution, the problem of error calculation will be considered, for it is with the help of such a calculation that one can both perform the calculation and determine qualitatively the confidence one can have in the solution obtained.

Once the β's in Equation 5b have been determined, it is possible to determine the mean square deviation in β. If it is assumed that the $A_{i\gamma}$ (i.e., the magnitude in the normalized library spectrum of the component γ in channel i) is known to be without error, the error in the β_γ calculation can then be obtained under the assumption that the statistical variations in the determination of the β_γ's are due to the statistical variation in the measurement of the $A_{i\gamma}$'s (Reference 10). Equation 5a can also be written

$$\beta_\lambda=\sum_i\sum_\nu C^{-1}_{i\lambda}A_{i\nu}\omega_i\rho_i, \tag{5b}$$

where $C=(\tilde{A}\omega A)$ is a symmetric matrix, the elements of C are

$$C_{\nu\gamma}=\sum_i \omega_i A_{i\nu}A_{i\gamma}, \tag{6}$$

and C^{-1} is the inverse of the matrix C. Thus,

$$CC^{-1}=I, \tag{7}$$

where I is the identity matrix and

$$I_{\nu\lambda}=\sum_\gamma C_{\nu\gamma}C^{-1}_{\gamma\lambda}. \tag{7a}$$

Now

$$I_{\nu\lambda}=1 \qquad \text{if } \nu=\lambda, \text{ and} \tag{7b}$$
$$I_{\nu\lambda}=0 \qquad \text{if } \nu\neq\lambda.$$

From Equation 5b, it is seen that β_λ is a linear homogeneous function of the counts ρ_i. Thus the mean-square deviation $\sigma^2(\beta_\lambda)$ corresponding to the variation in ρ_i can be written as

$$\sigma^2(\beta_\lambda)=\sum_i\sum_\nu\sum_\gamma C^{-1}_{\nu\lambda}C^{-1}_{\gamma\lambda}A_{i\nu}A_{i\gamma}\omega_i^2\sigma^2(\rho_i). \tag{8}$$

We now can consider the nature of ω_i. It was mentioned that

$$\omega_i\sim\frac{1}{\sigma_i^2}.$$

If we calculate $\omega_i=\frac{b}{\sigma_i^2}$, the Equation 8 reduces to

$$\sigma^2(\beta_\lambda)=b\sum_i\sum_\nu\sum_\gamma C^{-1}_{\nu\lambda}C^{-1}_{\gamma\lambda}A_{i\nu}A_{i\gamma}\omega_i$$

$$=b\sum_\nu\sum_\gamma C^{-1}_{\nu\lambda}C^{-1}_{\gamma\lambda}\sum_i\omega_iA_{i\nu}A_{i\gamma}.$$

From Equation 6

$$\sigma^2(\beta_\lambda)=b\sum_\nu\sum_\gamma C^{-1}_{\nu\lambda}C^{-1}_{\gamma\lambda}C_{\nu\gamma}$$

$$=b\sum_\nu C^{-1}_{\nu\lambda}\sum_\gamma C_{\nu\gamma}C^{-1}_{\gamma\lambda}.$$

Finally, from equation 7,

$$\sigma^2(\beta_\lambda)=bC^{-1}_{\lambda\lambda}:$$

that is, $\sigma^2(\beta_\lambda)$ can be found from the diagonal elements of the C^{-1} matrix, and if $\omega_i=\frac{1}{\sigma_i^2}$ then $\sigma_i^2(\beta_\lambda)$ is equal to the diagonal elements.

The goodness of fit can also be calculated and is used throughout the calculation. This is the so-called chi square value and is shown to be (Reference 11)

$$\chi^2=\frac{\sum_i\omega_i\left(\rho_i-\sum_\lambda\beta_\lambda A_{i\lambda}\right)^2}{n-m}, \tag{9}$$

where n is the number of channels and m is the number of components used in the fit. Thus $n-m$ is the number of degrees of freedom. It can be shown that the error calculated in $\sigma^2(\beta_i)$ is true only if chi square=1. If not, then

$$\sigma^2(\beta_i)=b\chi^2C^{-1}_{\lambda\lambda}. \tag{10}$$

This is the variance used in the calculations to follow.

It can be shown further that the off-diagonal elements $C^{-1}_{\gamma\lambda}$ are the covariance between the γth and λth component (References 11 and 12) and the percentage of interference $F_{\gamma\lambda}$ can then be calculated in the following manner:

$$F_{\gamma\lambda}=\frac{(C^{-1}_{\gamma\lambda})^2}{C^{-1}_{\gamma\gamma}C^{-1}_{\lambda\lambda}}\times100\%. \tag{11}$$

The $F_{\gamma\lambda}$ can also be considered as a measure of whether the set of library components A is truly a linearly independent set.

Method of Solution Using Nonnegativity Constraint

Consider the problem of how to determine the components of the A matrix when the set of components that should be used to perform a particular analysis is not known. Also consider the case where there are more components in the library than there are present in the mixture to be analyzed. In attempting to obtain the solution of Equation 5a directly by simple matrix multiplication and inversions negative solutions for the β_γ's can sometimes be obtained. These negative solutions are sometimes real in terms of the definition of the least square and are acceptable. However, what happens if the negative solutions are due to problems in the inversion of the matrix $(\tilde{A}\omega A)$? This can be attributed to the fact that the library function cannot be determined to a sufficient number of significant figures compatible with the accuracy required in obtaining $(\tilde{A}\omega A)^{-1}$. The presence of negative solutions can then cause oscillation in the solution. It was suggested by Burrus (Reference 5) that such oscillation could be damped out by using a nonnegativity constraint (that is, to require all components that go negative to be set equal to zero before any such oscillation can occur).

A method for introducing constraints into the solution of such equations was discussed by Beale (Reference 13). The technique de-

scribed herein is a method developed by the author based on the general consideration presented in Reference 13. Since the detailed proof is given in Reference 13, a geometric description of the solution will be presented herein to show the adaption of this technique to the particular problems discussed in this paper.

Consider the case of a measurement being made with a 3-channel pulse height analyzer. The following results are obtained.

Measured Spectrum

Channel (i)	Counts (ρ_i)
1	3
2	2
3	3

It is known that the measured spectrum is some linear combination of the following functions.

Library Components A

Channel (i)	Normalized Counts, Component 1 (A_{i1})	Normalized Counts, Component 2 (A_{i2})	Normalized Counts, Component 3 (A_{i3})
1	1	1	1
2	1	1	0
3	1	0	0

In this problem we assume that $\omega=\frac{1}{\rho}$.

$$A=\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 0\\ 1 & 0 & 0\end{bmatrix},$$

$$\omega=\begin{bmatrix}\frac{1}{3} & 0 & 0\\ 0 & \frac{1}{2} & 0\\ 0 & 0 & \frac{1}{3}\end{bmatrix},$$

and

$$\rho=\begin{bmatrix}3\\ 2\\ 3\end{bmatrix}$$

If these matrices and vectors are used in Equation 5b,

$$\beta=\begin{bmatrix}3\\ -1\\ 1\end{bmatrix}.$$

That is, the sum of vectors (1, 1, 1), (1, 1, 0), and (1, 0, 0) which yield the best fit to the experimental data using the least-square criteria is (3, 3, 3) − (1, 1, 0) + (1, 0, 0)=(3, 2, 3). The residual is zero.

The following example shows geometrically how the solution is obtained if the nonnegativity constraint is to be imposed. Equation 3 can be written as

$$M=8-6\beta_1-4\beta_2-2\beta_3+\frac{7\beta_1^2}{6}+\frac{5\beta_2^2}{6}+\frac{\beta_3^2}{3}+\frac{5\beta_1\beta_2}{3}+\frac{2\beta_1\beta_3}{3}+\frac{2\beta_2\beta_3}{3}.$$

The sum of the residuals M is to be minimized, and the constraints $\beta_1\geq 0$, $\beta_2\geq 0$, and $\beta_3\geq 0$ are to be applied.

Referring to Figure 5, we can follow the solution geometrically. Start at point 0, as-

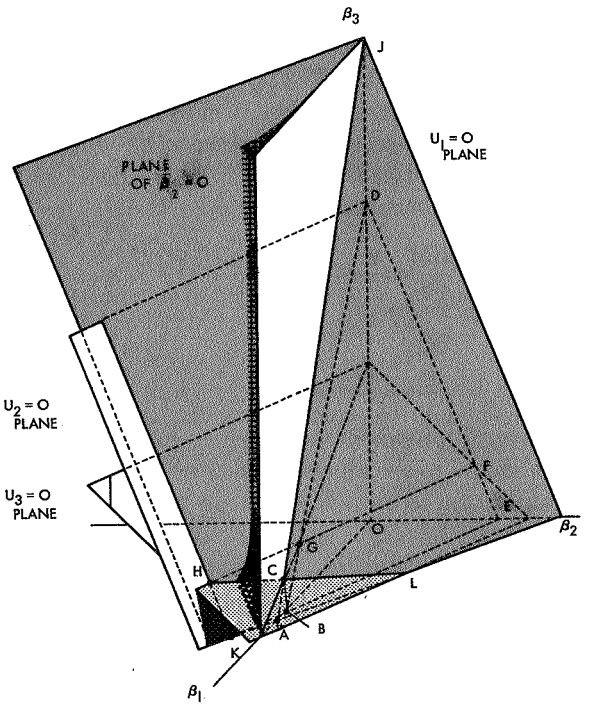


FIGURE 5.—A geometric solution of the least-square fit for the nonnegativity constraint.

suming $\beta_1=\beta_2=\beta_3=0$. Now keep $\beta_2=\beta_3=0$, and increase β_1 in a positive direction. As β_1 increases along this direction, M will be decreased until point A is reached. Point A is determined by taking the derivative of M with respect to β_1 and setting the derivative equal to zero with $\beta_2=\beta_3=0$. Thus,

$$\frac{\partial M}{\partial \beta_1}=-6+\frac{7\beta_1}{3}+\frac{5\beta_2}{3}+\frac{2\beta_3}{3}=2U_1.$$

Then for $U_1=\beta_2=\beta_3=0$, $\beta_1=18/7$ and the coordinates of point A are (18/7, 0, 0). The plane $U_1=0$ in the space described by β_1, β_2, and β_3 contains all points β_1 for which M is a minimum, given any values of β_2 and β_3.

Continuing the solution, it is found that increasing β_1 any further will only increase M. A change of bases is now made. The value β_1 is found in terms of U_1, β_2, and β_3. Thus

$$\beta_1=\frac{6}{7}\left(U_1+3-\frac{5\beta_2}{6}-\frac{\beta_2}{3}\right).$$

Keeping $U_1=\beta_3=0$, one changes β_2 in attempting to decrease M; that is, β_2 is increased or decreased by moving along the line of intersection of the $U_1=0$ plane and the $\beta_3=0$ plane. This intersection is along the line $\overline{AKL}$ indicated in Figure 5. The problem now is to determine which direction to move along $\overline{AKL}$ so that M decreases. This can be done by taking the derivative of M with respect to β_2 and then substituting U_1 for β_1:

$$\frac{\partial M}{\partial \beta_2}=\frac{2}{7}+\frac{10\beta_2}{21}+\frac{4\beta_3}{21}+\frac{10U_1}{7},$$

or at

$$\frac{\partial M}{\partial \beta_2}=\beta_3=U_1=0,\ \beta_2=-\frac{3}{5}.$$

That is, β_2 must become negative to decrease M. This cannot be allowed because of the constraints; therefore, β_2 must be made zero. In this case $\beta_2=U_2'$, and substitution is made again. The plane $U_2'=0$ is the plane of all values of β_2 given any β_1 and β_3 for which M is a minimum with the constraints of the problem. This then sets $\beta_2=0$.

Starting at point A, an attempt is made to minimize M by increasing β_3 from zero along the line $\overline{ACJ}$, the intersection of the $U_1=0$ and $U_2'=0$ planes. The direction and amplitude of β_3 required for β_3 to reamin a minimum is found by taking the derivative of M with respect to β_3 and solving the equation in terms of β_3, U_1, and U_2:

$$\frac{\partial M}{\partial \beta_3}=\left(-\frac{2}{7}\right)+\frac{10\beta_3}{21}+\frac{4U_2}{21}+\frac{4U_1}{7}=2U_3,$$

and then for $U_3=U_2'=U_1=0$, $\beta_3=3/5$. This value of β_3 along with the value of $\beta_2=U_1=0$ can be substituted in the expression for β_1, so that

$$\beta_1=\frac{6}{7}\left[3-\frac{1}{3}\left(\frac{3}{5}\right)\right]=\frac{12}{5}.$$

This is point C in Figure 5 and corresponds to the intersection of the $U_1=0$, $U_2'=0$, and $U_3=0$ planes. This is then the solution of the problem with the constraint that there be no negative solutions:

$$\beta=\left(\frac{12}{5},\ 0,\ \frac{18}{7}\right)$$

The absolute minimum (3, −1, 1) can also be found by continuing the solution and defining a U_2 plane of minima similar to the method for β_1 and β_2. When this plane is used and the intersection of the planes $U_1=0$, $U_2=0$, and $U_3=0$ is found, the point of intersection will be the absolute minimum. This is the point H in Figure 5.

The method applied to a case where there are n values of β_n to be determined can be outlined as follows:

1. Using Equation 3, obtain $M=M(\beta_1, \beta_2, \beta_3 \ldots \beta_n)$.

2. Obtain the derivative of M with respect to β_1 (it is not necessary to obtain the derivatives in any given order if the set of library functions forms a linearly independent set). Then let

$$U_1=\frac{\partial M}{\partial \beta_1}.$$

3. Let $U_1=\beta_2=\beta_3=\ldots=\beta_n=0$, and solve for β_1. If $\beta_1>0$, then solve for β_1 in terms of U_1, $\beta_2 \ldots \beta_n$, and make a change of bases.

4. Now obtain the partial derivative with respect to β_2. Let

$$U_2=\frac{\partial M}{\partial \beta_2},$$

and set $U_1=U_2=\beta_3. \ldots .=\beta_n=0$, and solve for β_2. If $\beta_2>0$, then solve for β_2 in terms of U_1, U_2, $\beta_3 \ldots \beta_n$ and again make the change in bases. If $\beta_2<0$, then let $\beta_2=U_2'$ and substitute this value for β_2 in the change of bases. Other constant constraints on β_2 or on another of the β's can impose these constraints and make change of bases consistent with the constraints. Therefore, the solution described is more general than that demonstrated in the previous problem.

5. The foregoing procedure is continued for all β's. At each step, the values for all the β's considered up to that point are determined. If any of these β's are negative, one makes the change of variables $\beta_k=U_k'$. Furthermore, if a previous change of variable was made introducing $U_k=\frac{\partial M}{\partial \beta_k}$, U_k must be eliminated using the relationship $U_k'=\beta_k$ before continuing the iterative process.

6. The n values of β are found after the last iteration by setting all the values of U and U' equal to zero.

The solution just discussed is equivalent to the following matrix approach. Assuming that the measured distribution is made up of only two components (e.g., the A_{i1}'s and the A_{i2}'s), one can use least-square fitting to obtain the β_1 and β_2 from Equation 5b. It has been assumed that $\beta_3=\beta_4=\ldots .=\beta_n=0$. If $\beta_1>0$ and $\beta_2>0$, then one adds a third component, and solves for β_1, β_2, and β_3. If any of these β's are negative, that given β is set equal to zero, and the corresponding library function is eliminated from the library matrix A. In this way, each component is tested until only a positive or zero magnitude is found for all the components under consideration.

Oscillations which are produced in the solution by negative values are damped out before causing any difficulties. Conceptually, the process can be described in the following manner. The number of pulse height library spectra are fitted applying least-square criteria to a complex spectrum made up of some subset of these library spectra. Obtaining solutions consists of choosing a number of library spectra which are less than, or equal to, the number of components in the complex mixture. The fits are made to the total pulse height spectra. Since the number of components used in the fit are less than, or equal to, the actual number of components in the mixture, the relative intensities β obtained will be greater than or equal to their true values. As the components are added to the library in the manner previously described, the magnitudes of the β's will decrease and approach their true value. Thus, if a component when added to the library yields a negative magnitude for β, the addition of more components will make this value decrease or become more negative. Therefore, setting this component equal to zero will tend to damp out the oscillation before perturbing the final solution.

Finally, the order in which components are library spectrum should not influence the solution obtained if the set of library functions is linearly independent. The method of testing the criteria and corrections that can be made to compensate for linear dependence or correlations between various components will be discussed later in this paper.

Compensation for Gain Shift and Zero Drift

The method of solution as described up to this point has assumed that the problem is linear; that is, in Equation 4, the derivative of M was taken only with respect to β_γ. This assumes that the pulse height versus energy scale for the library components, the various components in the library, and the measured pulse height spectrum to be analyzed are all the same. In many cases, this is not true. Nonlinear methods could be used possibly to overcome this difficulty. Two major difficulties arise in the application of this method. First of all, the derivative of the monoelemental, or monoenergetic library components would have to be obtained. Errors introduced in obtaining these derivatives from empirical measurements can be extremely large and therefore can greatly

degrade the solution. Furthermore, iterative methods used to find the solution of this nonlinear equation are complex and long, and in many cases great difficulty arises in finding a method to converge upon a solution. It has therefore been decided to use linear methods and to compensate for nonlinearities in the data preparation before inputting to the least-square program.

There are two types of changes of pulse height energy scales of interest in this problem. One change is the gain shift. This change can be considered as a compression or expansion of the one pulse height scale with respect to the second scale. The second change, the zero drift, can be considered as a linear displacement of one scale with respect to the other. Thus, in general, these two changes can be expressed as

$$P_{ji}=gP_{ki}+\epsilon, \tag{12}$$

where

P_{ji} is the channel number i for spectrum j,
P_{ki} is the channel number i for spectrum k,
g is the gain shift, and
ϵ is the zero displacement.

In order to perform the linear least-square analysis, g must equal 1, and ϵ must equal zero.

The spectrum to be changed is described by ρ_{ki}, where ρ_{ki} is the total counts in channel P_{ki} of spectrum k. To change the kth spectrum so that it is on the same scale as the j spectrum, the following procedure is used if g and ϵ are known. The pulse height scale P_{ki} is multiplied by g, and the intensity scale ρ_{ki} is divided by g. It must be remembered that the pulse height spectra can be considered as histograms. The integral under the pulse height distribution must remain constant. The procedure just described for compensating for gain shift will keep this area a constant.

It is important to point out that the spectra used in the least-square analysis is included for integer values of pulse height, which are separated by $\Delta P_{ji}=1$. The gain is shifted by some value g which could produce intensity ρ_{ji} values at fractional values of pulse height P_{ki}/g and cause ΔP_{ki} to become either less than or greater than unity. For example, consider the case for $g=0.98$ and $g=2.0$. Channels 10 and 11, for example, will become channels 9.8 and 10.78, respectively, for $g=0.98$ and channels 20 and 22, respectively, for $g=2.0$. For the first case, $g=0.98$, values of P_{ki}/g must be found at channels 10, 11, etc.; for the second case, $g=2.0$, values of P_{ki}/g must be found at channels 20, 21, 22, etc. The values at channel 11 ($g=0.98$) or at channel 21 ($g=2.0$) are found by linear extrapolation between two points (channels 9.8 and 10.78 for $g=0.98$ and channels 20 and 22 for $g=2.0$). This extrapolation is included as an integral part of the program. Higher order polynomial extrapolation has also been used, but the linear extrapolation has been found to be just as good for this technique.

Next, compensation is made for a zero drift. This is accomplished by changing the pulse height scale $g\ P_{ki}$ to $g\ P_{ki}+\epsilon$. There need be no operation on the intensity values ρ_{ki}, for this linear displacement does not change the value of the integral under the pulse height distribution. Compensation for ρ_{ki} being at noninteger values of $g\ P_{ki}+\epsilon$ and for the fact that $\Delta(gP_{ki}+\epsilon)$ may not be unity is made by using the linear extrapolation method previously mentioned.

Compensations for both gain shift and zero drift have been included in the program developed at this laboratory. Figure 6 shows the results of gain shifting on a spectrum with $g\sim0.70$ to match the library spectrum. The spectrum was obtained using a proportional counter filled with P–10 gas and a 256-channel multichannel analyzer. Characteristic X-rays produced by α-particle bombardment of sand samples were measured. The circles represent the measured spectrum; the triangles represent the gain shifted spectrum; and the solid line shows the synthesized spectrum using the least-square fit. The agreement is extremely good.

The program that has been developed at the laboratory will compensate for a constant value of gain shift or a zero drift or, given a lower and upper limit for a gain shift or zero drift, will search for the proper value between the limits given. The criteria which are used to find

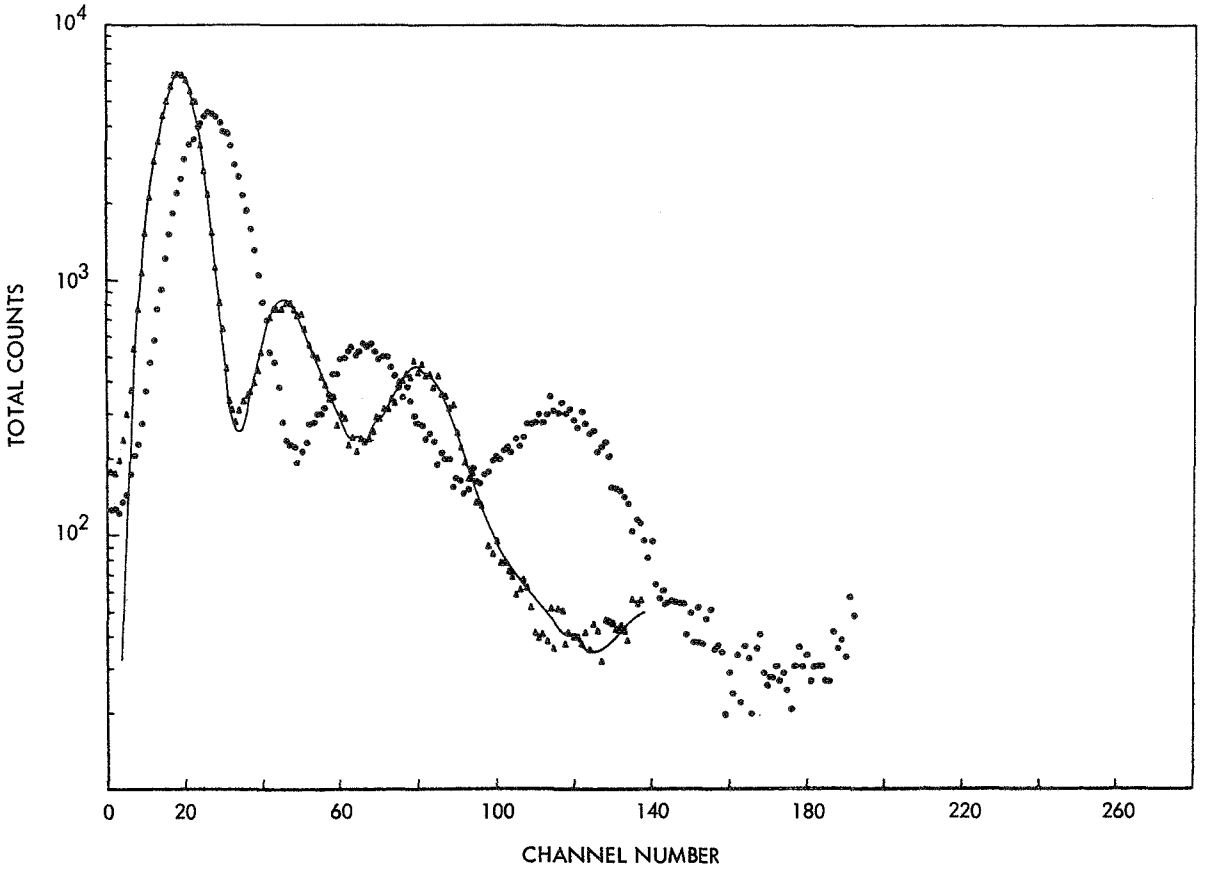


FIGURE 6.—Effect of gain shift; sample of silty sand from Hopi Butte, Arizona.

the best gain shift g and zero drift ϵ in the given interval is that value g and ϵ be chosen such that chi square be defined in Equation 9 as a minimum. The procedure used to find this minimum chi square is as follows. The least-square fit is performed for the minimum and maximum values of g in the given range. Then a fit is made for a value of g in the middle of the range. Again fits are made for values of g in the interval midway between the upper and middle value of g, and then the middle and lower value of g. The chi square obtained each time is always compared with the smallest value obtained previously. This process of halving the range and determining the smallest chi square for these values of g is continued until the difference between two successive tests is smaller than some predetermined limit. In the case of the program developed at this laboratory, experience has shown that this number is 0.01.

Once the value of g has been found, this gain-shifted spectrum is used as the input spectrum to the zero drift search program. The same iterative process is used to determine the best value of ϵ in the zero drift program as was used for the gain shift search.

The precision to which the values can be determined will depend strongly on the resolution of the detector system since the better the resolution, the sharper and steeper will be the shape of the library function and the measured spectrum. The sharper the shape of these functions, the greater will be the change in chi square for small changes in g or ϵ.

Furthermore, it has been found that the gain shift has greater sensitivity for the higher pulse height region while, for the zero drift

procedure, the lower pulse height part of the spectrum shows greater sensitivity. This can be shown if one considers, for example, a gain shift of $g=0.96$ and a zero drift of $\epsilon=1.0$. Consider now channel 10 and channel 200 as they undergo a gain shift of 0.96, and assume that there is a peak in each of these channels. The peak that was in channel 10 will now appear in channel 9.6, and the peak in channel 200 will now appear in channel 192. The shift at the low pulse will be hardly discernible (0.4 of a channel), while the shift at the higher channel will be quite noticeable (8 channels). Similarly, if one now consider the zero drift $\epsilon=1.0$ without a gain shift, a peak in channel 10 will now appear in channel 11, a 10 percent change, while a peak in channel 200 will now appear in channel 201, a 0.5 percent change. It is believed that, because of the difference in sensitivity of gain shift and zero drift to pulse height the computer routine developed first to find the g shift, without zero drift compensation, and then to determine the zero drift for a constant g shift seems to work well.

Preparation of the Library

One of the most important factors in obtaining reasonable results with the technique described in this paper is that the library functions (i.e., A_{ij}'s used in Equation 5) must be known as well as possible. Careful preparation of the library standards, long counting times of these standards, repeated measurement of these standards, proper background compensation, and proper linearity compensation are necessary to obtain a set of library functions which will yield meaningful results. For the proper application of the technique and for the proper calculation of errors, the correlations and chi square, the error in the knowledge of the library function, must be significantly less than the error in the measurement of the complex spectrum to be analyzed.

Problems in sample preparation and counting statistics will not be considered in this paper, but problems related to background compensation and linearity correction will be considered. First the linearity problem will be considered in this section, and then the general problem of the background compensation will be taken up in the next section.

When we talk of the linearity problem, what is meant is that the energy pulse height scale must be the same for all the library functions used in a given analysis. Even when great care is taken in measuring the standards, small gain shifts and zero drifts can and do occur so that there may be small changes in the scale. Two approaches may be used to make the correction. First of all, the energy versus pluse height scale can be determined carefully, and then each component can be checked with respect to this scale, and, using gain shift and zero drift programs again, each component corrected for a common scale.

The second approach is the one used in this method. Each monoenergetic or monoelemental spectrum is measured separately, and a number of mixtures of these elements are also measured. The monoelemental components are then varied (both gain shifted and zero drifted) separately in order to obtain a best fit to the mixture spectrum. For example, consider the case of a mixture of Na^{22} (sodium), Cs^{137} (cesium), and Co^{57} (cobalt). The pulse height spectra of each of these elements are shown in Figures 1, 2, and 3; the pulse height spectra of the mixture are shown in Figure 4. The procedure used to adjust the spectra can be described as follows.

1. The fit is started with Na^{22} and considers only the highest energy line at 1.274 Mev. Gain shift and zero drift compensation calculations are made so as to obtain a best fit (based on least-square) from channel 80 up. The Na^{22} spectrum after this compensation is then stored in the library.

2. The next highest energy spectrum, that is, the spectrum for Cs^{137}, is adjusted just as in step 1, except that the region of interest is now from channel 40 up. This covers the region including the 0.51 Mev line of Na^{22}, the 0.661 line of Cs^{137}, and, of course, the higher energies considered in step 1. The adjusted spectrum for Na^{22} is also used in the attempt to find the best fit for Cs^{137}. When the adjusted spectrum is found, it is then stored in the library with the Na^{22} spectrum.

3. The third spectrum for Co^{57} is then brought in and adjusted as previously described until a best fit is obtained using the adjusted Cs^{137} and Na^{22} spectra. The total pulse height scale is used in this fit. The Co^{57} spectrum is then stored in the library after adjustment for gain shift and zero drift.

The adjusted spectra can then be used in the main program, and quite an improvement can be obtained. For example, Table 1 shows the results of the least-square fit before and after library adjustment. The spectrum analyzed is the mixture spectrum shown in Figure 4. The gain shift and zero drift for each component are also indicated. The true relative intensity of the mixture is also shown.

The great improvement in the chi square value indicates the greater confidence that can be realized in the solution. Furthermore, with even these small gain shift and zero drift compensations, there is a great improvement in the results obtained.

The library adjustment program can be used in an iterative mode also. That is, after the first adjusted library spectra are obtained, the order of fitting of the mixture spectrum may be changed so that the emphasis can be placed, for example, on the lower pulse height region, which is more sensitive to zero drift; or emphasis can be placed on the higher pulse height region, which is more sensitive to gain shift. The program, as developed, allows for setting lower and upper limits on the region of the pulse height spectrum to be considered.

When libraries containing larger numbers of components are used, it may be necessary to use mixtures of only a few components at a time in order to obtain the best linearity adjustments.

CORRELATION AND RESOLUTION

Let us now consider what is meant by the linear independence of the library functions. The number obtained using Equation 11 is a measure of how different, or how well, one component or library spectrum can be resolved with respect to a second component. It can also be considered as a measure of whether the components in the library of standard spectra can be considered to be linearly independent.

As an illustration of how Equation 11 is used, assume that the library function or monoelemental function can be described by Gaussians:

$$A_{i\lambda}=\exp-\frac{(i-P_\lambda)^2}{2\alpha_\lambda^2}, \tag{13}$$

where $A_{i\lambda}$ is the counts in channel i due to the λth component, α_λ^2 is a measure of the width of the Gaussian for energy λ, and P_λ is the position on the pulse height spectrum corresponding to energy λ.

Now let us calculate the percentage of interference between two monoenergetic pulse height spectra with Gaussian form using Equation 11 and a shape given by Equation 13. If we assume that $\omega=1.0$, Equation 11 becomes

$$F_{\gamma\lambda}=\frac{\left(\sum_i A_{i\gamma}A_{i\lambda}\right)^2}{\sum_i (A_{i\gamma}^2)\sum_i (A_{i\lambda}^2)}. \tag{14}$$

TABLE 1.—*Results of the Least-Square Analysis of the Mixture of Co^{57}, Cs^{137}, and Na^{22} Before and After the Application of the Library Preparation Technique*

Monoelemental Component	Gain Shift	Zero Drift	True Relative Intensity	Relative Intensity Before Library Adjustment	Relative Intensity After Library Adjustment
Co^{57}	1.002	−0.004	0.200	0.185±0.013	0.193 ±0.005
Cs^{137}	1.002	−0.074	0.200	0.099±0.013	0.202 ±0.002
Na^{22}	1.048	0	0.100	0.102=0.004	0.0101±0.006
chi square				114.	2.2

Using equations of the form given in Equation 13 and replacing the summation by an integral from — infinity to + infinity, Equation 14 becomes

$$F_{\gamma\lambda}=\frac{2\alpha_\lambda\alpha_\gamma}{\alpha_\lambda^2+\alpha_\gamma^2}\exp-\left(\frac{P_\lambda-P_\gamma}{\alpha_\gamma^2-\alpha_\lambda^2}\right). \quad (15)$$

Defining the resolution R_λ gives

$$R_\lambda=\frac{W_{1/2}}{P_\lambda}, \quad (16)$$

where $W\frac{1}{2}$ is the total width of the peak at half the maximum amplitude. Furthermore, it can be assumed for many spectroscopic problems of interest that the resolution R_λ is inversely proportional to some power of energy or pulse height P_λ; that is

$$R_\lambda\sim P_\lambda^{-n}. \quad (17)$$

If it is assumed that $n=0.5$, then

$$\frac{R_\lambda}{R_\gamma}=\sqrt{\frac{P_\gamma}{P_\lambda}}. \quad (18)$$

Furthermore α_λ can be rewritten in terms of R_γ and P_γ as $A_{i\lambda}=\frac{1}{2}$. Then

$$\alpha_\gamma=\frac{R_\gamma P_\lambda}{2\sqrt{2\ln 2}}. \quad (19)$$

Substituting the relationships in Equations 18 and 19 into Equation 15, we get for this special case

$$F_{\gamma\lambda}=\frac{2\sqrt{P_\lambda P_\gamma}}{P_\lambda+P_\gamma}\exp-\left[\frac{P_\gamma(P_\lambda-P_\gamma)^2}{(P_\lambda-P_\gamma)\alpha_\lambda^2}\right]. \quad (20)$$

Figure 7 is a plot of Equation 20 for various detector resolutions as a function of the percentage of separation $(P_\gamma-P_\lambda)/P_\lambda$ for decreasing P_γ. If $P_\gamma=P_\lambda$, the Gaussians are identical, and the percentage of interference is 100 percent. As the percentage of separation increases, the percentage of interference decreases. The number $F_{\gamma\lambda}$ is (in this case) thus a measure of how well two Gaussians can be resolved.

Consider how this number can be practically interpreted. Assume the case of two Gaussians separated in mean value by 10 percent. The resolution for the energy at the maximum mean position is 20 percent. From Figure 7, $F_{\gamma\lambda}$ is 50 percent. This then means that, if these two functions were used in least-square analysis, the relative intensities β_γ and β_λ can be determined only with the following precision. The sum $\beta_\gamma+\beta_\lambda$ can be determined with an error which will be the sum of these individual variances calculted from the diagonal elements of $(\tilde{A}\omega A)^{-1}$, but either β_γ or β_λ can be varied by 50 percent, keeping the sum $\beta_\gamma+\beta_\lambda$ constant, and the fit based on the least-square criteria will be just as good.

In general, given a library of functions A, the percentage of interference between various components can be determined by forming $(\tilde{A}A)^{-1}$ and calculating $F_{\gamma\lambda}$. It is usually a good procedure to test the library function before performing the least-square analysis. This will give some idea of how much confidence there can be in the results obtained for the relative intensities of the individual components.

If two functions do interfere strongly, it is sometimes possible to impose a physical constraint which can eliminate the interference. For instance, in the problem in activation analysis utilizing gamma-ray spectroscopy, a

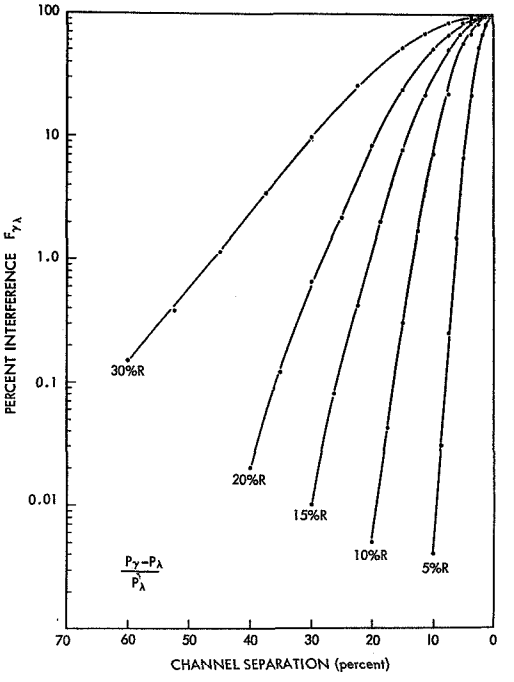


FIGURE 7.—Percentage of interference for various resolutions.

physical constraint which depends on the half-life of the various nuclear species in the mixture that is being analyzed can be used. The following procedure is used for the case of two nuclear species with different half-lives. Assume that the half-life of the second of these two components is the longest. Pulse height spectra are obtained as a function of time. Spectra are measured until the short half-life has decayed out, for all practical purposes. A number of measurements are made for the longer half-life component. When the short half-life component has decayed out, the correlation between the two components will go to zero. The intensity of the second component with the longer half-life can now be determined. Knowing the relative intensity as a function of time and its half-life, the intensity of the second component can be extrapolated back to the earlier times. The second component can then be subtracted out for these earlier times when both components are present, the analysis repeated with the second component eliminated from the library, and the relative intensity of the first component determined with the correlation eliminated. An example of the utilization of this technique will be presented in the last section.

Another example of the use of constraints to eliminate correlations can be given for the case of X-ray fluorescence. Figure 8 shows the measured pulse height spectrum obtained using powdered basalt rock as the sample to be analyzed. In the low-energy region, it seems that both silicon (Si) and aluminum (Al) are present.

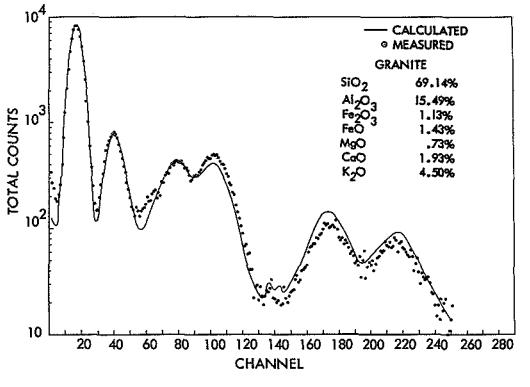


FIGURE 8.—X-ray fluorescence pulse height spectrum obtained with a P–10 gas-flow proportional counter using a Cm^{242} α-excitation source.

At least-square analysis was performed, and it was found that there was 45 percent correlation between aluminum and silicon. Here a second pulse height spectrum was obtained using an aluminum foil filter which strongly absorbed the silicon X-rays. Figure 9 shows the measured pulse height spectrum (the circle) and the synthesized curve obtained from the least-square fit with the Si component removed. A pure Al sample was also measured with and without the filter. From this, the absorption coefficient is determined, and the intensity of the aluminum line was determined. Once this intensity was determined, the aluminum component was subtracted from the pulse height spectrum obtained without the filter, and the silicon component determined without interference. The improvement in both qualitative and quantitative analyses when these correlations are removed is shown in the work presented in Reference 7.

When a component or components are subtracted from the pulse height spectrum, the error due to this subtraction must be included in the calculation. This procedure is carried out in the computer program.

The percentage of interference previously described has only considered the problem of energy or elemental resolution; however, there are two other effects which may produce high correlations. In one case, the statistical error due to total counts, background subtraction, or component subtraction may be so high that

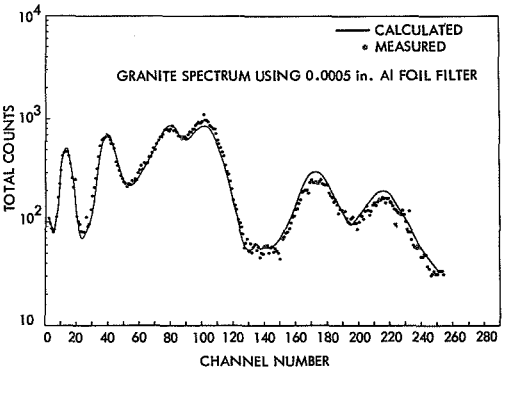


FIGURE 9.—X-ray fluorescence pulse height spectrum obtained with a P–10 gas-flow proportional counter using a Cm^{242} α-excitation source and a 0.0005-inch-thick aluminum foil placed over the window of the detector.

the percentage of interference will be large. This will be related to the statistical weight matrix ω in the $(\tilde{A}\omega A)^{-1}$. Secondly, interference can occur between two library components if the library is incomplete. There is then the possibility that the two components on either side of a missing component will be underestimated or overestimated to make up for the missing element: in some cases a correlation between these adjacent elements will be observed. When a calculation is made of the difference between the measured spectrum and the calculated spectrum using least-squares, a negative or positive peak will appear at the position of the missing element. The width of these negative or positive peaks must be greater than, or equal to, the half-width as calculated from the resolution of the energy in order to interpret the peaks obtained in the difference spectra (i.e., measured spectrum versus calculated spectrum) as real. The measured spectrum (corrected for gain shift and zero drift), the calculated spectrum (using intensity obtained from least squares), and the difference spectrum are all part of the computer output of the program developed for this calculation.

Physical Constraints

Physical constraints such as nonnegativity, half-life, and absorption are used in order to obtain a unique solution. The importance and utilization of such factors cannot be overemphasized. Since the approach taken in obtaining these solutions is semi-empirical, the more information introduced into the method of obtaining the solution, the faster the solution will be obtained, and the more certain that the solution is unique and correct. What must be remembered is that each time such a constraint is used in the solution one increases the statistical error in the solution. For example, the nonnegativity constraint requires that the solution be obtained in the positive domain only. The difference given by Equation 3 is a minimum in this domain, but, because of the constraints, is not necessarily the absolute minimum. As was shown, for example, in the example described in the section on the nonnegativity constraint, if one of the components (β_2) were allowed to go negative, Equation 3 would be smaller (in fact go to zero). Furthermore, when the subtraction method is included in the calculation, the statistical deviation in the counts will be increased because of the subtraction which will in turn increase the standard deviation in the calculation of the relative intensities.

Finally, the technique for obtaining the minimum in the positive domain can be extended to determine the minimum in domains which are constrained by other physical constraints (e.g., half-lives). This can be done, for example, in the following way. For those components that do not have physical constraints, the following planes of minima are defined:

$$U_x=\frac{\partial M}{\partial \beta_\lambda}=0, \tag{21}$$

where M and β_λ are defined in Equation 3 and, for those components that have, let us say, a constraint B_γ, the planes U' of constraints are found to be

$$U'_\gamma=\beta_\gamma=B_\gamma. \tag{22}$$

The intersection of these planes will be a point which will be the minimum for M in the domain defined by the various constraints. Algorithms other than those used in this paper for obtaining solutions to problems using such constraints can be found in Reference 13.

Background Compensation

At first thought, this problem should be rather simple to handle. For example, a background is measured for either the same time or a time shorter or longer than the measurement of the unknown system, and then the background is subtracted with adjustment being made for the counting time. But a number of problems do enter which tend to complicate this problem. For example:

1. Possible shift of the pulse height scale with respect to either the library function scale or the scale of the measured unknown spectrum.

2. Possible nonlinear effects which complicate the problem of finding the proper intensity of background to subtract.

3. The inclusion of the statistical error due to background subtraction in the calculation of the least-square fit.

Consider each problem separately. The first problem, that of background gain shifts and zero drift, can be handled in a number of different ways. First of all, the technique used for the library preparation can be used. In this approach, the pure background spectrum is measured, and then a second mixture spectrum is measured. This mixture spectrum is obtained using a source which is characteristic of one of the standards in the library. This second standard spectrum must be low enough in energy so that there will be no significant correlation between these two functions (i.e., the standard and background) so that these functions can be considered as linearly independent. The mixture spectrum is then measured, and the standard library function and the pure background spectrum are used and adjusted using the library preparation program so that a best fit to the mixture spectrum is obtained. In this way, the gain shift and zero drift factors can be determined. Provision is made in the least-square analysis program to make such constant adjustment of the pulse height scale for the background before subtraction from the measured complex spectrum which is to be analyzed.

Alternately, if it is assumed that the background has shifted with respect to the library exactly as has the complex spectrum to be analyzed, then there is provision in the program to vary the background spectrum between the same limits as prescribed for the spectrum which is being analyzed, and a search for a minimum chi square helps to determine the best gain shift and zero drift values for both. These routines for gain shift and zero drift compensation before going into the main least-square analysis and those and later steps to be described can be considered as data input preparations for the main program.

Now consider problem (2) previously described, that of the nonlinearity in determining the intensity of the background spectrum to be subtracted. This particular problem is encountered in the application of the technique to the analysis of pulse height spectra obtained in nondispersive X-ray fluorescence analysis (see Reference 7). The background in this problem can be considered as comprised of two components, one which is attributed to the natural radioactivity in the surroundings, and a second component which is due to coherent scattering from the sample of X-radiation originating at the excitation source. It is the fluorescent X-radiation produced in the irradiated sample, not the scattered radiation, which is of interest in the analysis. The amount of background radiation due to scattering will be affected by the nature of the sample (average atomic number, density, etc.). Thus the background to be subtracted will be determined, not only by the scattering source, but also by the sample being irradiated.

A few words about the procedure for this experiment are necessary before describing the method used for compensating for background for a source of alpha particles such as Cm^{242}. The alpha particles from this source bombard a sample, and characteristic X-rays are produced. A gas proportional counter with a multichannel analyzer is used to measure the characteristic X-ray pulse height spectra. Figure 10 shows the measured X-ray pulse height spectrum obtained using a Cm^{242} source and P-10 proportional counter. The various monoelemental components, including background, making up the spectrum are also shown. The following method is used to compensate for the presence of the background. The spectrum shown in Figure 10 was measured over a pulse height range greater than that which would be necessary in order to measure the highest energy expected to be emitted from the irradiated sample. The spectrum in this higher energy region will thus be due only to background. A background spectrum using a strong scatterer such as a boric acid in the sample position is taken. The characteristic X-rays from boric acid are outside the range of detection of this system (see Figure 11). From previous experience, it was found that the spectral shape of the background curve was not greatly affected by the scatterer, although the intensity was affected. The background spectrum is then included as a library component and used in the least-square fit. The

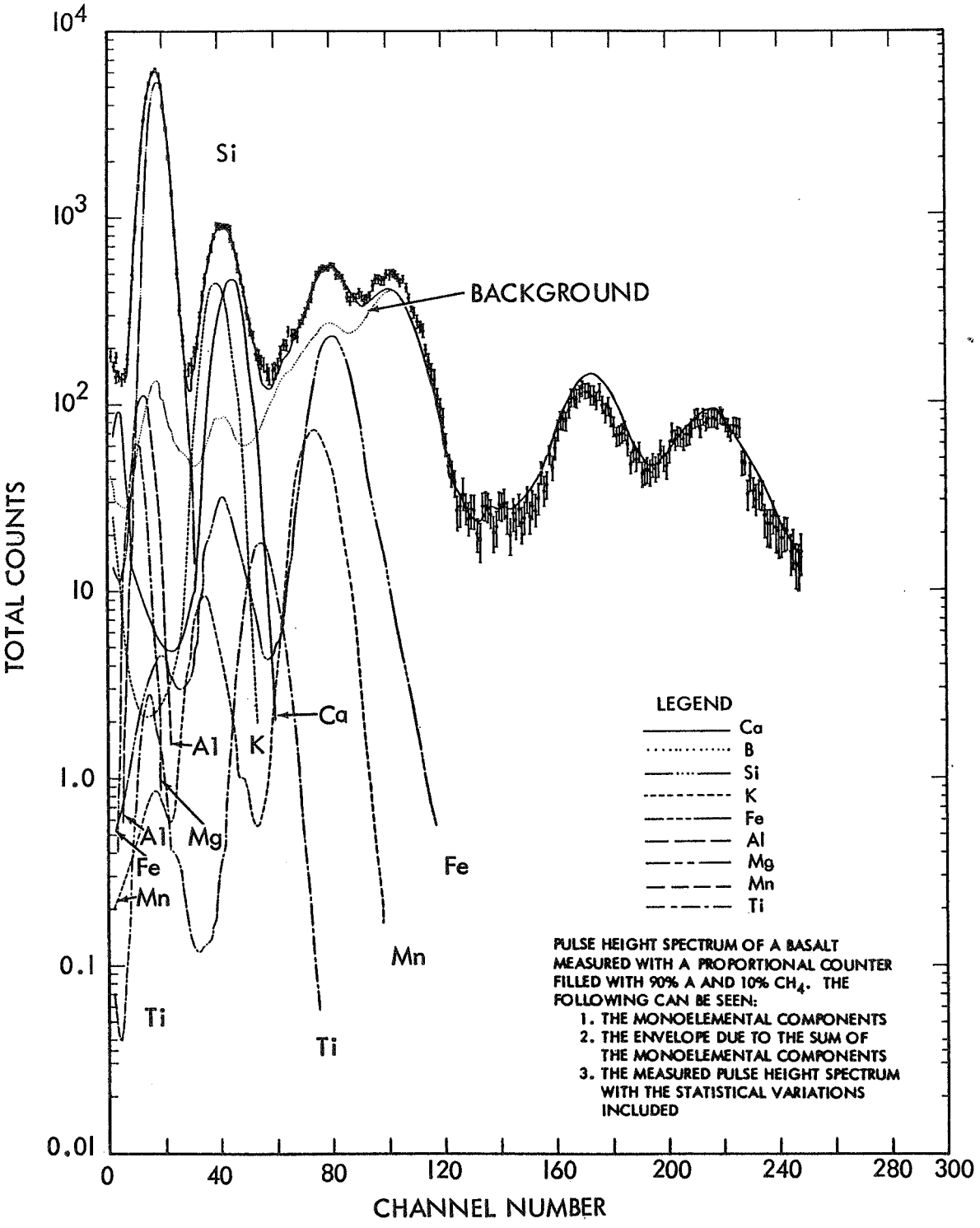


FIGURE 10.—Pulse height spectrum of a basalt measured with a proportional counter filled with A (90 percent) and CH_4 (10 percent).

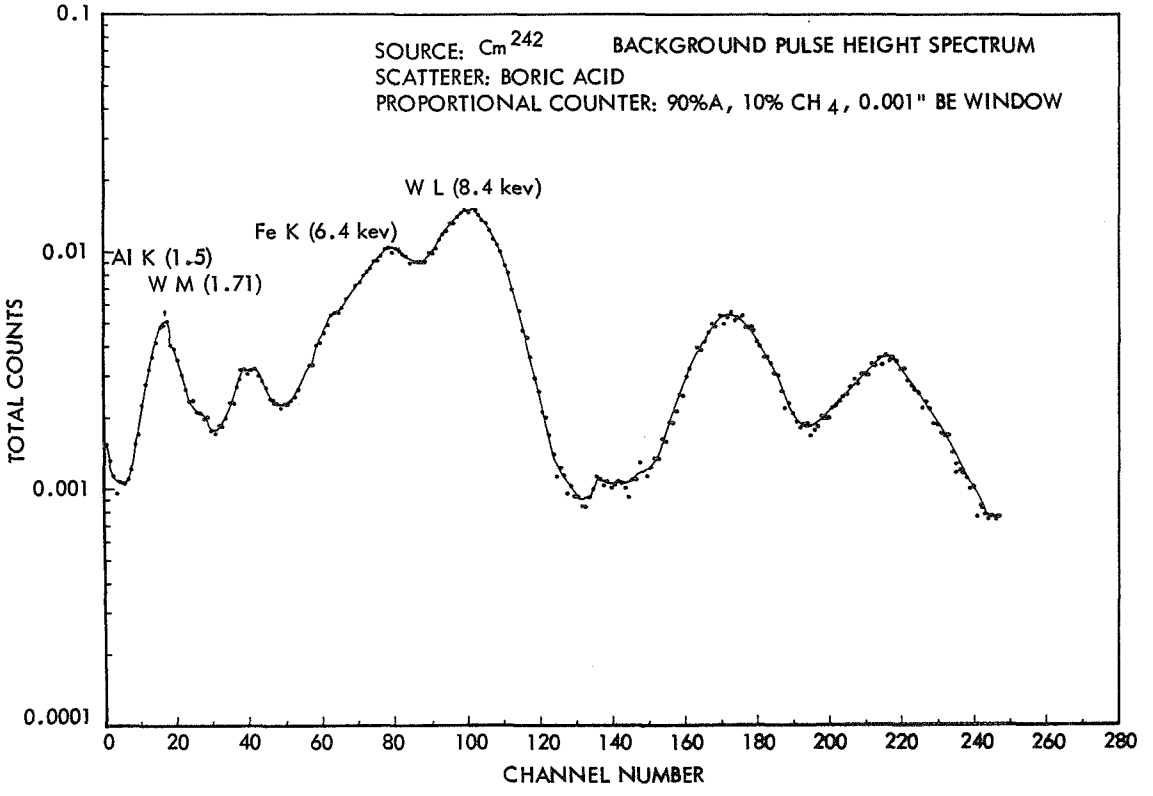


FIGURE 11.—Background pulse height spectrum using a Cm^{242} source, boric acid as scatterer, and a proportional counter filled with A (90 percent) and CH_4 (10 percent) and fitted with a 0.001-inch Be window.

effect of background is taken into account in this way. In practice this approach can be used only when there is a significant portion of the pulse height spectrum which can be attributed to the background only. If this were not the case, the background spectrum would strongly correlate with many of the monoenergetic or monoelemental library components, and a unique solution would not be obtained.

The final problem concerning the error due to background subtraction is now considered. In calculating the statistical weight ω and the variance in the relative intensity β, the increase in statistical variance due to background subtraction is automatically included in the computer program developed at the laboratory. This correction is made only if the background subtraction is performed in the program. If, for example, the subtraction is done on the multichannel analyzer and all that is available is the spectrum with background subtracted, then the calculation of the statistical error from the diagonal elements of inverse matrix $(\tilde{A}\omega A)^{-1}$ will not be correct for ω. Provision is made for the program to input the proper information on error calculations which are done outside the program. This is done essentially by reading in a corrected ω matrix.

In the case where the background is included as a library element, proper compensation for statistical variance in the background will be difficult if not impossible. Therefore, in order to use this technique properly, the background must be measured so that the statistical variance in measurement of the background is significantly less than in the spectrum to be analyzed.

OUTLINE OF THE COMPUTER PROGRAM

A detailed description of the structure of the computer will be presented in Appendix A. Only a brief outline of the computer program will be presented here. Figure 12 is a flow diagram of this program.

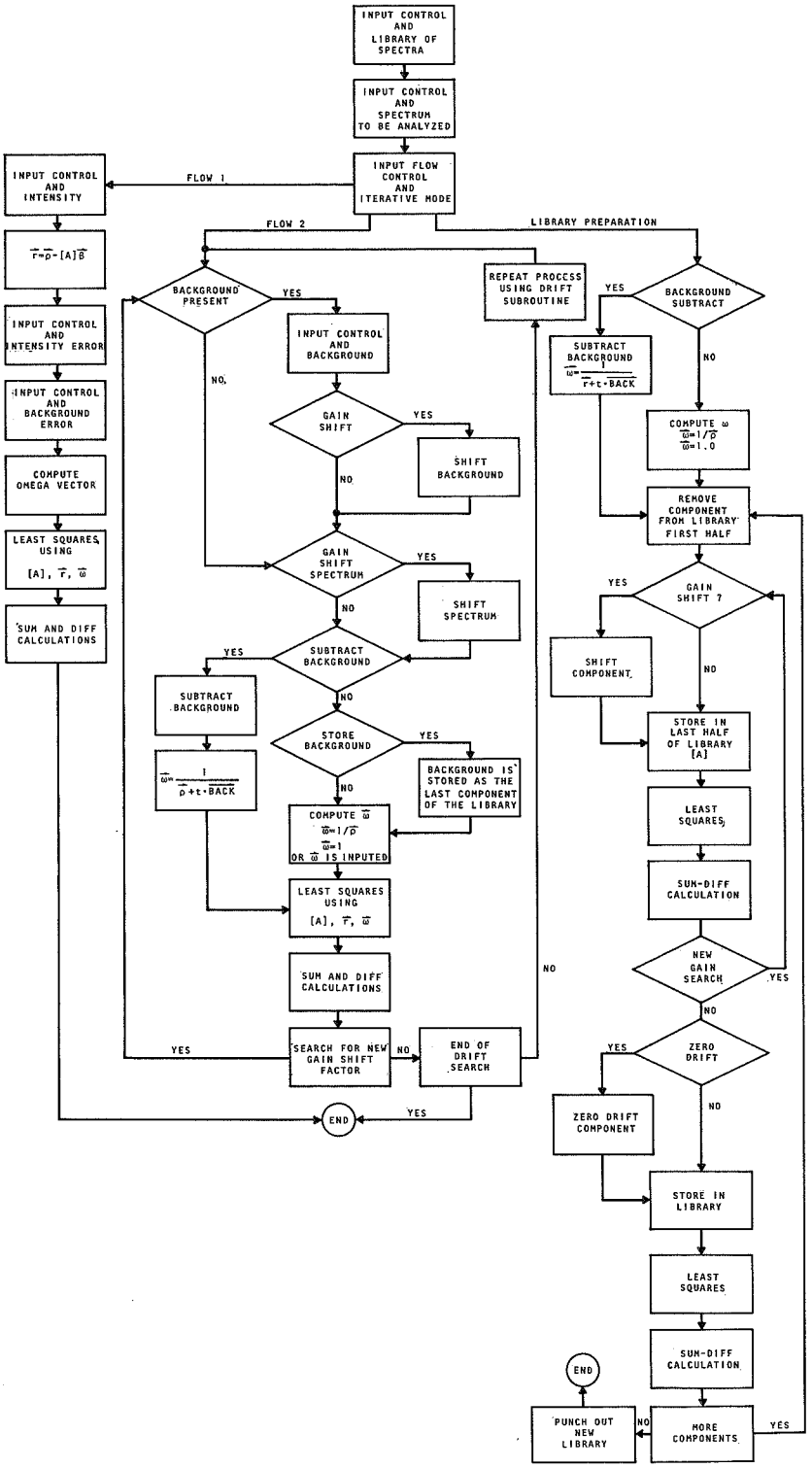


FIGURE 12.—Flow diagram of least-square analysis computer program.

The general input to the program is always the library spectra followed by the spectrum to be analyzed. After this point, a decision is made on the mode of analysis to be used: Flow 1 (component subtraction and least-square), Flow 2 (background subtraction, gain-shift compensation, zero-drift compensation, and least-square analyses) and Flow 3 (the library preparation mode).

First consider Flow 2. After the library and data have been read in, a decision is asked for to determine whether there is a background. If there is a background, it is read in, and a decision is made whether to gain shift the background. For gain shift, there are two modes: either a constant gain shift can be used, or a search on gain can be imposed. If there is no background, or after the background gain shift has been performed, a decision is asked as to whether the data are to be gain-shifted, whether the gain shift is constant, or whether to search for the gain shift factor. Once this decision is made and the spectrum data gain-shifted if necessary, the background is examined, if present. Two choices are again available: either the background is to be stored as a library component, or it is to be subtracted from the data spectrum. If the background is stored in the library, or if there were no background, a decision must be made concerning how to calculate the ω matrix. Three choices are available: (1) $\omega=\frac{1}{\rho}$, where ρ stands for the data spectra; (2) $\omega=I$, where I is the unity matrix: (3) ω is read in on cards (this allows for independent calculations).

If the background is to be subtracted, the subtraction from the data spectrum is carried out, and the ω vector is calculated setting $\omega=\frac{1}{\rho+T\,(\text{back})}$, where T is the fraction of background to be subtracted.

At this point, the data have been prepared for input to the least-square program. Another decision is then made, whether the absolute minimum is to be found and Equation 5a solved allowing for negative solution, or the minimum is to be found in the positive domain and the technique described in the section on the nonnegativity constraint used in solving Equation 5a. The least-square analysis is performed: the relative intensities, the standard deviation, and the percentage of interference are obtained at this point. If the nonnegativity constant is used, the components that are rejected are printed out. Now the gain shift, the background-subtracted spectrum, the synthesized spectrum, the difference spectrum, and chi square are obtained. In the search mode for gain shift for either background, data, or both, the chi square is stored for the three iterations (i.e., using the maximum, minimum, and mid value). These values are compared and an iteration is tried midway between the lowest values. This iteration continues until the difference in the value of the gain after two successive iterations is less than 0.01, and the minimum value of chi square is chosen. After the last iteration, all the information obtained in the preceding calculation is printed out.

Finally a decision is required on whether a zero drift compensation calculation is to be made. If such a calculation is required, then the routine just described is followed except that the zero drift routine is substituted for the gain shift routine.

Flow 1 usually uses the output of Flow 2 as an input but can also use an input independent of Flow 2. The procedure is rather straightforward. The relative intensities and the corresponding standard deviations of the components to be subtracted from the data spectrum are read into memory. These standards are then subtracted from the data spectrum. Calculation of the ω matrix, considering the variance on the data spectrum due to counting statistics, background subtraction, and standard subtraction is carried out, and the least-square analysis is then performed. The option for the absolute minimum or the minimum in the positive domain is also allowed in this mode. The output obtained is the same as that described for Flow 2.

Consider the library preparation program. In this case the input of library components and data are the same. It should be remembered that the data input is the mixture spectrum for use in obtaining the library spectra on a

common scale. The background subtract or storage option and the options for calculating ω, similar to that available in Flow 2, will not be discussed here. The storage positions for the library components are divided into two parts. The library components before gain shift and zero drift corrections are stored in the second half of this storage position, and in the first half after the compensation has been made.

Components are removed one at a time from the last half of the storage position. The range over which the analysis is to be performed is determined. The options of gain shift constant or search and zero drift constant or search are allowed, and the calculation proceeds after this point as described in Flow 2. After the calculations and zero drift and gain shift compensations have been made, the component is stored in the first half of the library storage area and is used in the succeeding calculations. After all the components have been stored, an option is available for obtaining a punched card output in the proper format for input to the program at a later time.

Application of Least-Square Technique to an Experimental Problem

The solution to an experimental problem in activation analysis will be presented in this section. A set of standard library measurements was obtained by irradiating the following materials in a nuclear reactor: Na (sodium), Cl (chlorine), K (potassium), Mn (manganese), Sc (scandium), A (argon), As (arsenic), Cu (copper), Cr (chromium), I (iodine), and La (lanthanum) (see Figures 13 through 23). Background spectra were also run. Figure 24 shows one of the background spectra used. The library and background were adjusted to be on a common pulse height scale, and the contaminants indicated in the illustrations of library components were subtracted. A mixture of these elements was prepared and then irradiated in the reactor. Gamma ray pulse height spectra of these mixtures were then measured from time

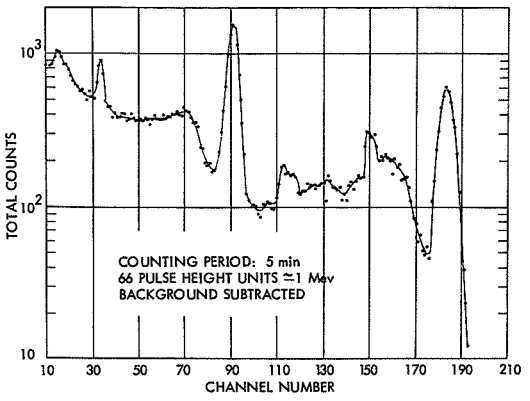


FIGURE 13.—Pulse height spectrum of Na^{24} standard.

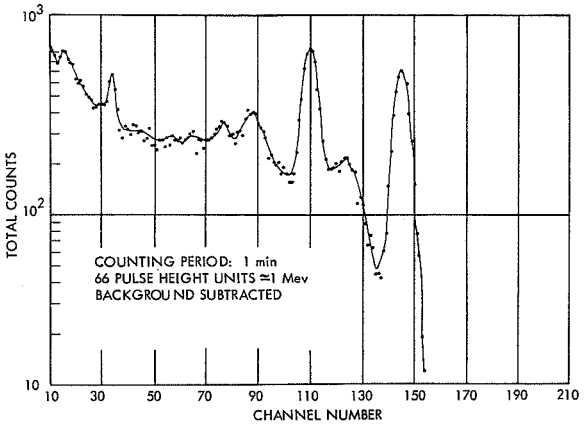


FIGURE 14.—Pulse height spectrum of Cl^{38} standard.

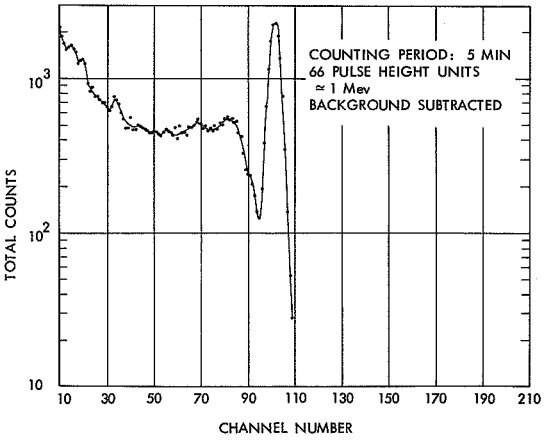


FIGURE 15.—Pulse height spectrum of K^{42} standard.

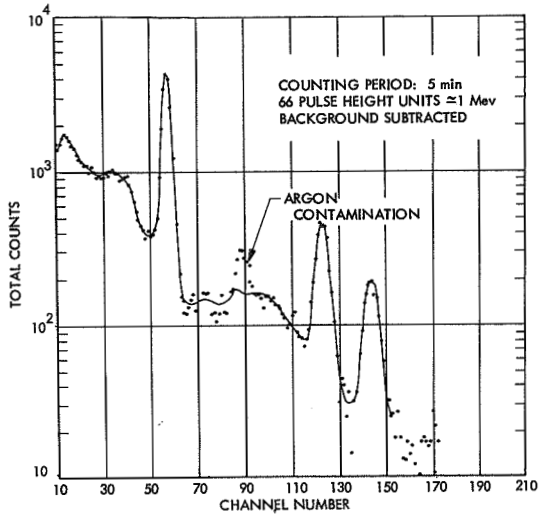


FIGURE 16.—Pulse height spectrum of Mn^{56} standard.

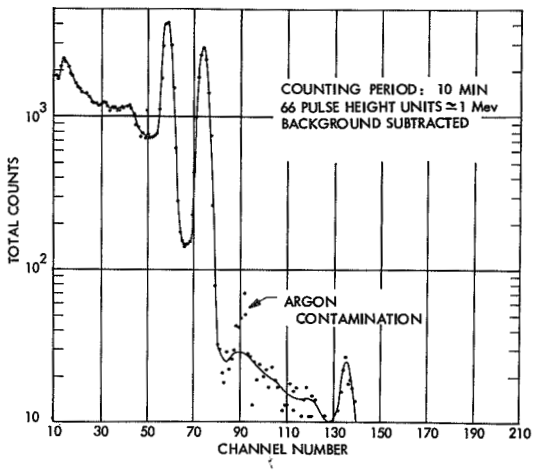


FIGURE 17.—Pulse height spectrum of Sc^{46} standard.

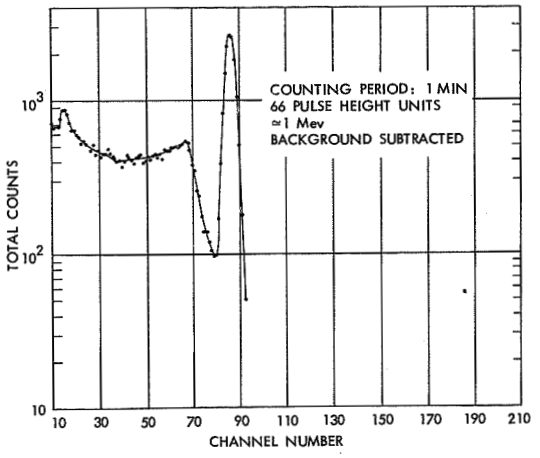


FIGURE 18.—Pulse height spectrum of A^{41} standard.

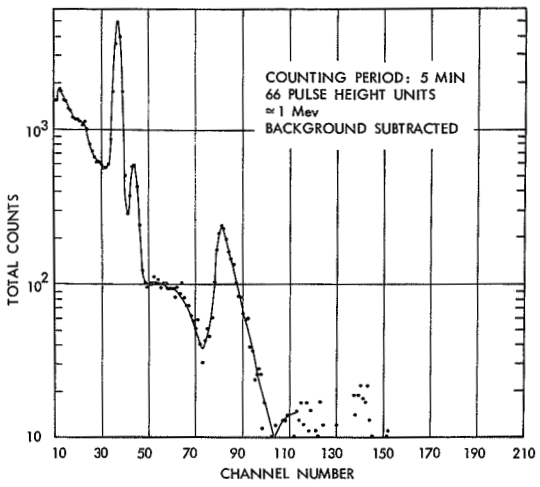


FIGURE 19.—Pulse height spectrum of As^{76} standard.

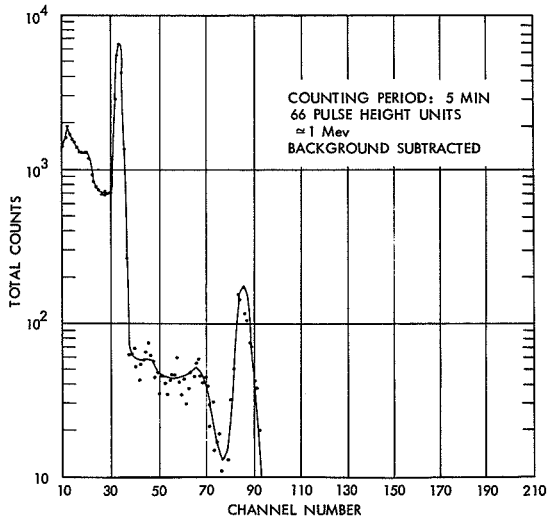


FIGURE 20.—Pulse height spectrum of Cu^{64} standard.

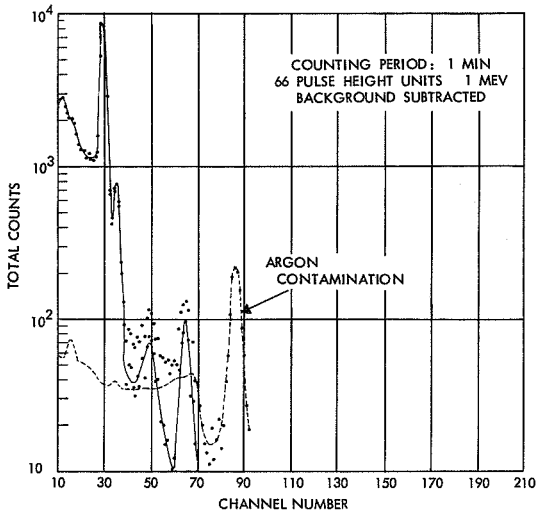


FIGURE 22.—Pulse height spectrum of I^{128} standard.

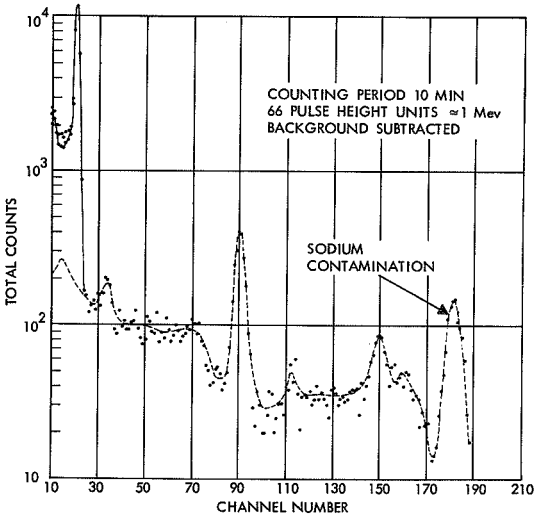


FIGURE 21.—Pulse height spectrum of Cr^{51} standard.

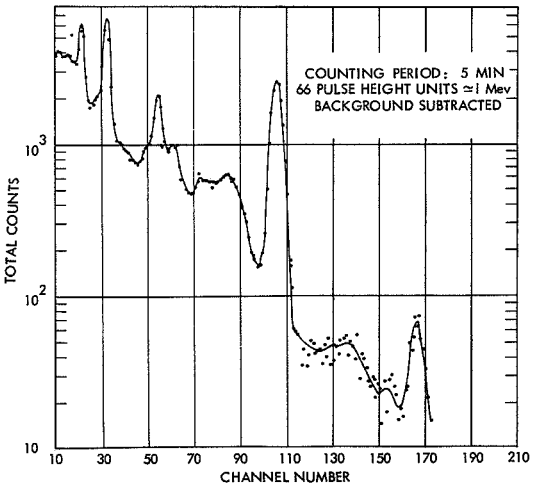


FIGURE 23.—Pulse height spectrum of La^{140} standard.

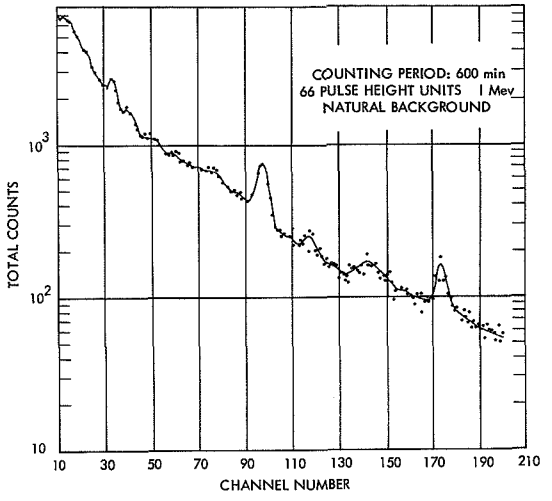


FIGURE 24.—Pulse height spectrum of background.

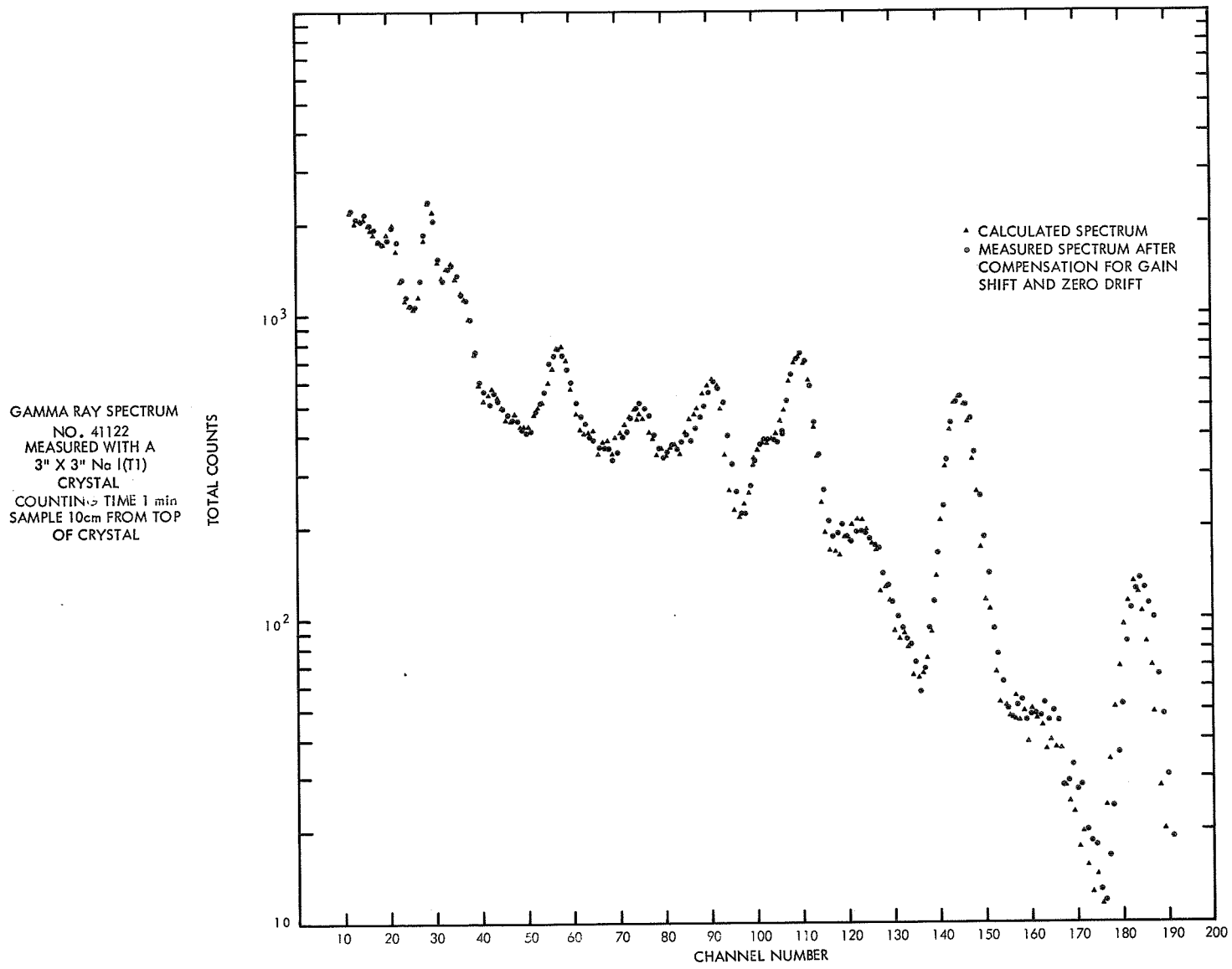
periods of a few minutes to a number of days after exposure (Figures 25 through 33). The circles are the measured spectra, and the triangles are the synthesized spectra obtained from the least-square fit with gain shift and zero drift adjustments. At the bottom of this figure is the difference spectrum that is obtained by subtracting the actual spectrum from the measured spectrum and dividing the difference by the value of the actual spectrum.

A tabulation of the monoelemental components that significantly correlated, using the least-square method with the non-negativity constraint with the percentage of interference obtained, is shown in Table 2.

TABLE 2.—*Interference*

Element	Na	Sc	La
Cl	14. 50		
Mn		40. 5	
K			21. 4
Cu			13. 4
Cr			12. 9

It was decided to determine the intensities of the Na, Sc, and La components. From the half-life curves, the intensities of these components were determined for the earlier time. These components were then subtracted from the nine pulse height spectra, and the relative intensities for Cl, Mn, K, Cu, and Cr were recalculated as a function of time. Using the nonnegativity constraint, the argon component was rejected each time and set equal to zero. Arsenic and iodine did not correlate significantly with any other component; therefore the values obtained before component subtraction were considered to be correct.


GAMMA RAY SPECTRUM
NO. 41122
MEASURED WITH A
3" X 3" Na I(T1)
CRYSTAL
COUNTING TIME 1 min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER
CALCULATED SPECTRUM
MEASURED SPECTRUM AFTER
COMPENSATION FOR GAIN
SHIFT AND ZERO DRIFT

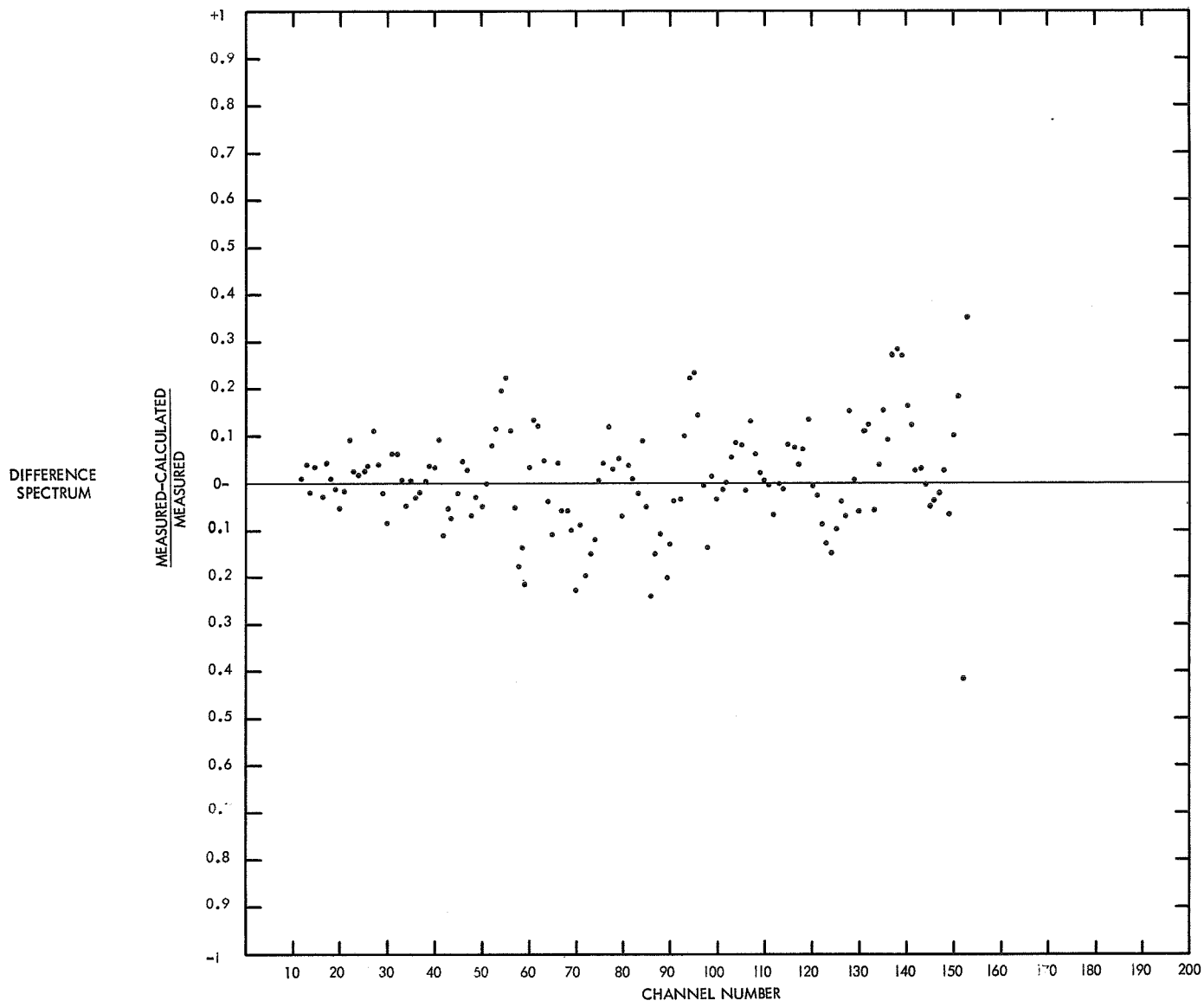
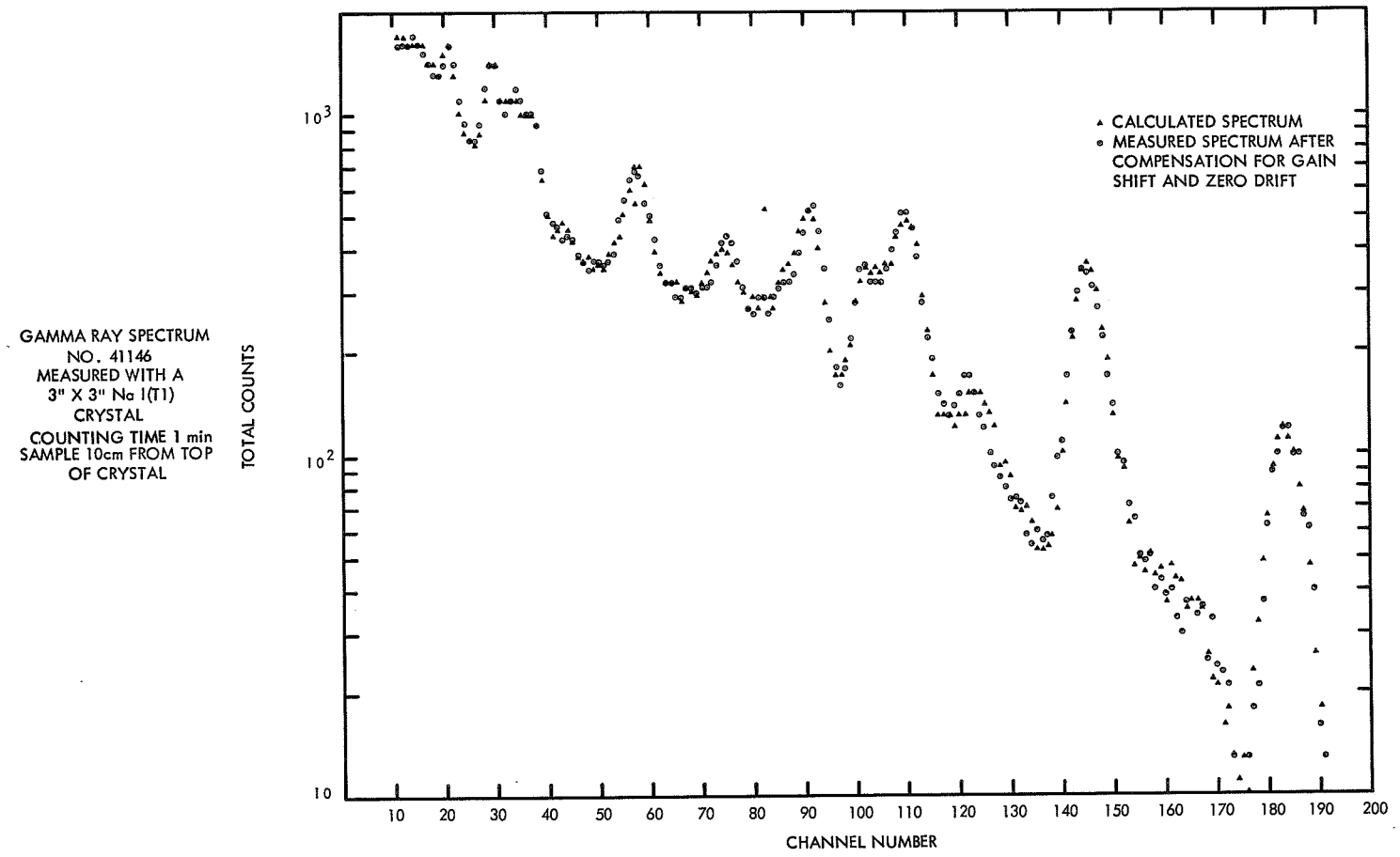


FIGURE 25.—Pulse height spectrum of mixture no. 41122.


GAMMA RAY SPECTRUM
NO. 41146
MEASURED WITH A
3" X 3" Na I(T1)
CRYSTAL
COUNTING TIME 1 min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10³
10²
10
CALCULATED SPECTRUM
MEASURED SPECTRUM AFTER
COMPENSATION FOR GAIN
SHIFT AND ZERO DRIFT
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER

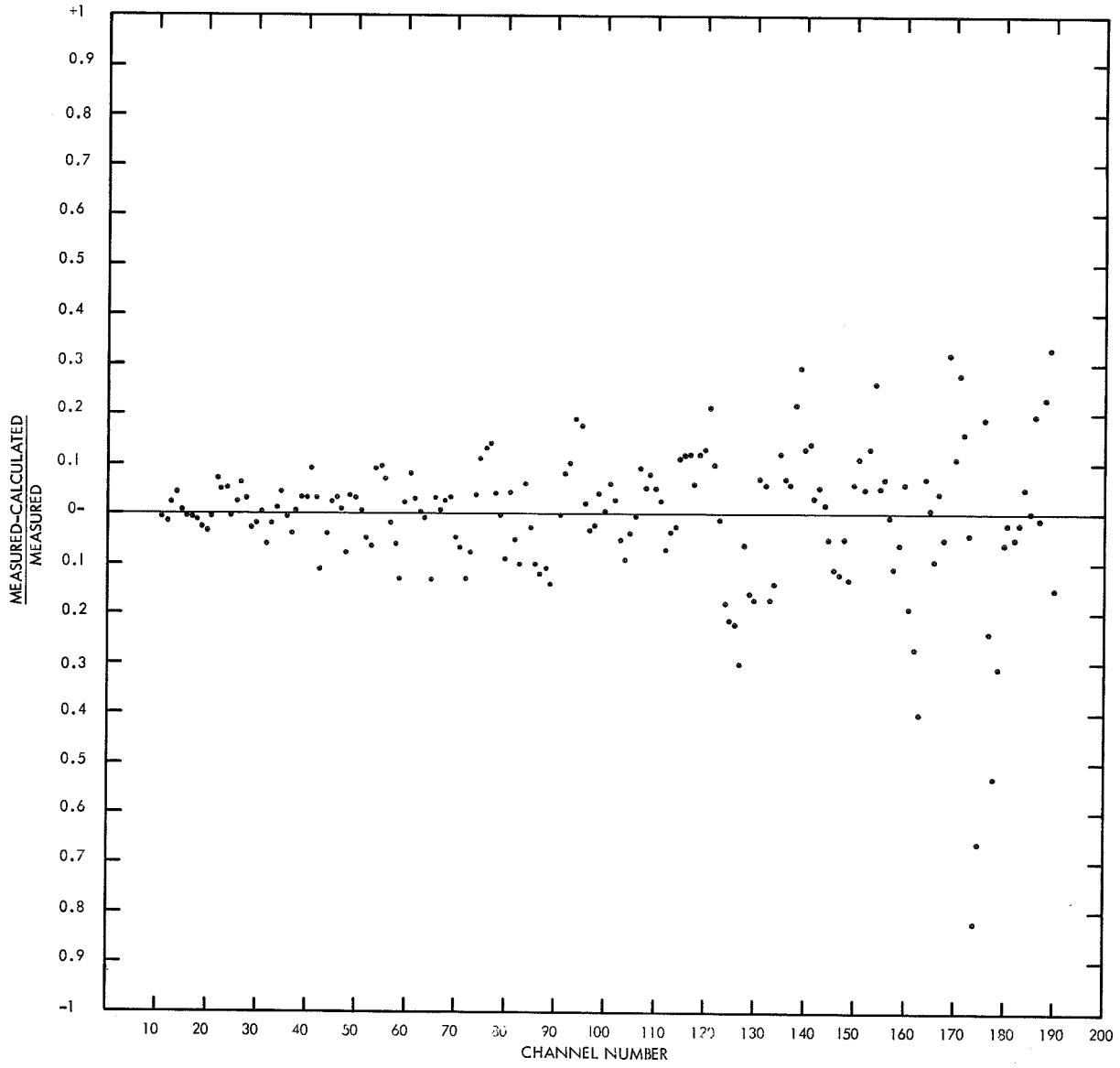
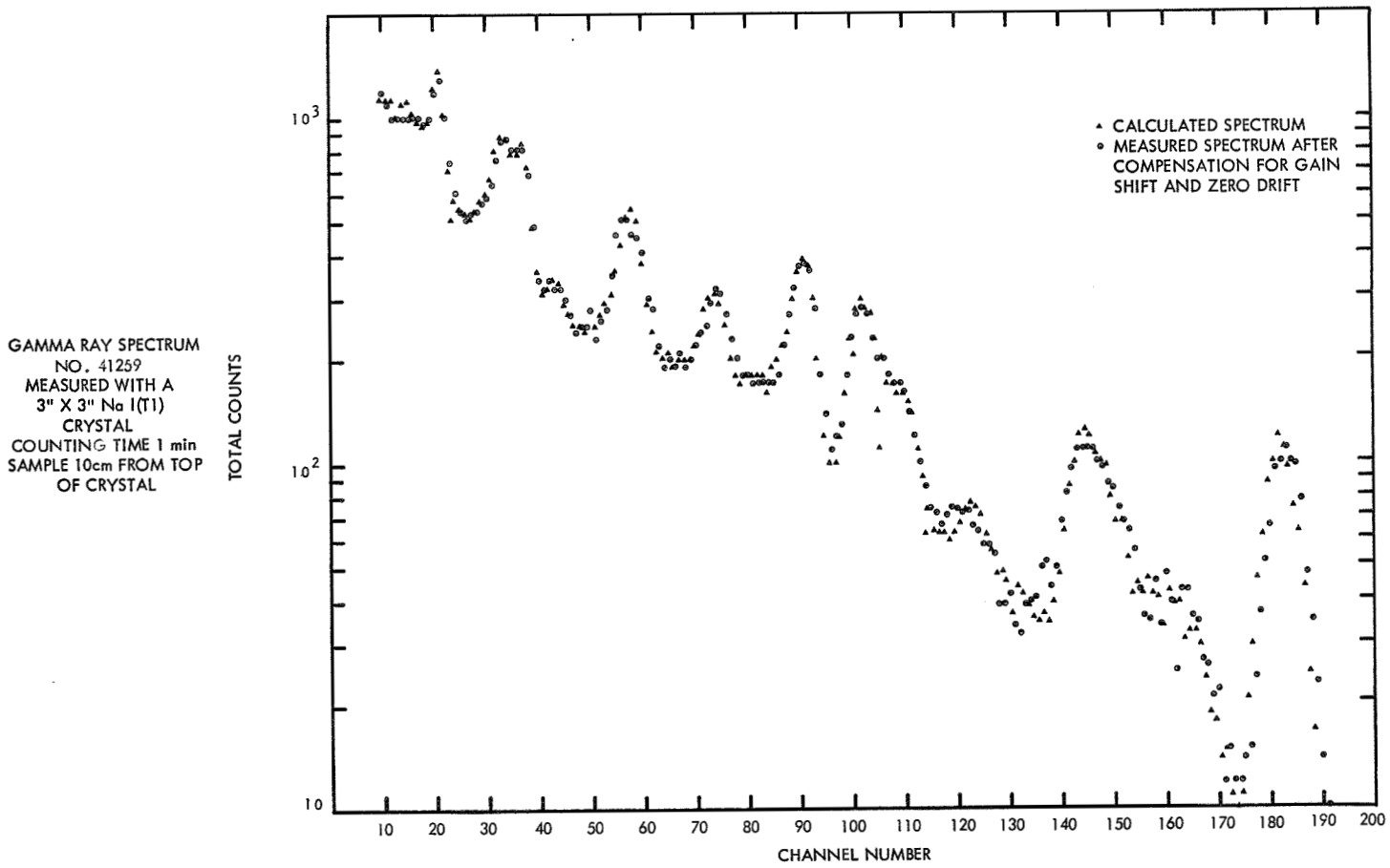


FIGURE 26.—Pulse height spectrum of mixture no. 41146.

292-232 O—68——3


GAMMA RAY SPECTRUM
NO. 41259
MEASURED WITH A
3" X 3" Na I(T1)
CRYSTAL
COUNTING TIME 1 min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10^3
10^2
10
CALCULATED SPECTRUM
MEASURED SPECTRUM AFTER
COMPENSATION FOR GAIN
SHIFT AND ZERO DRIFT
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER

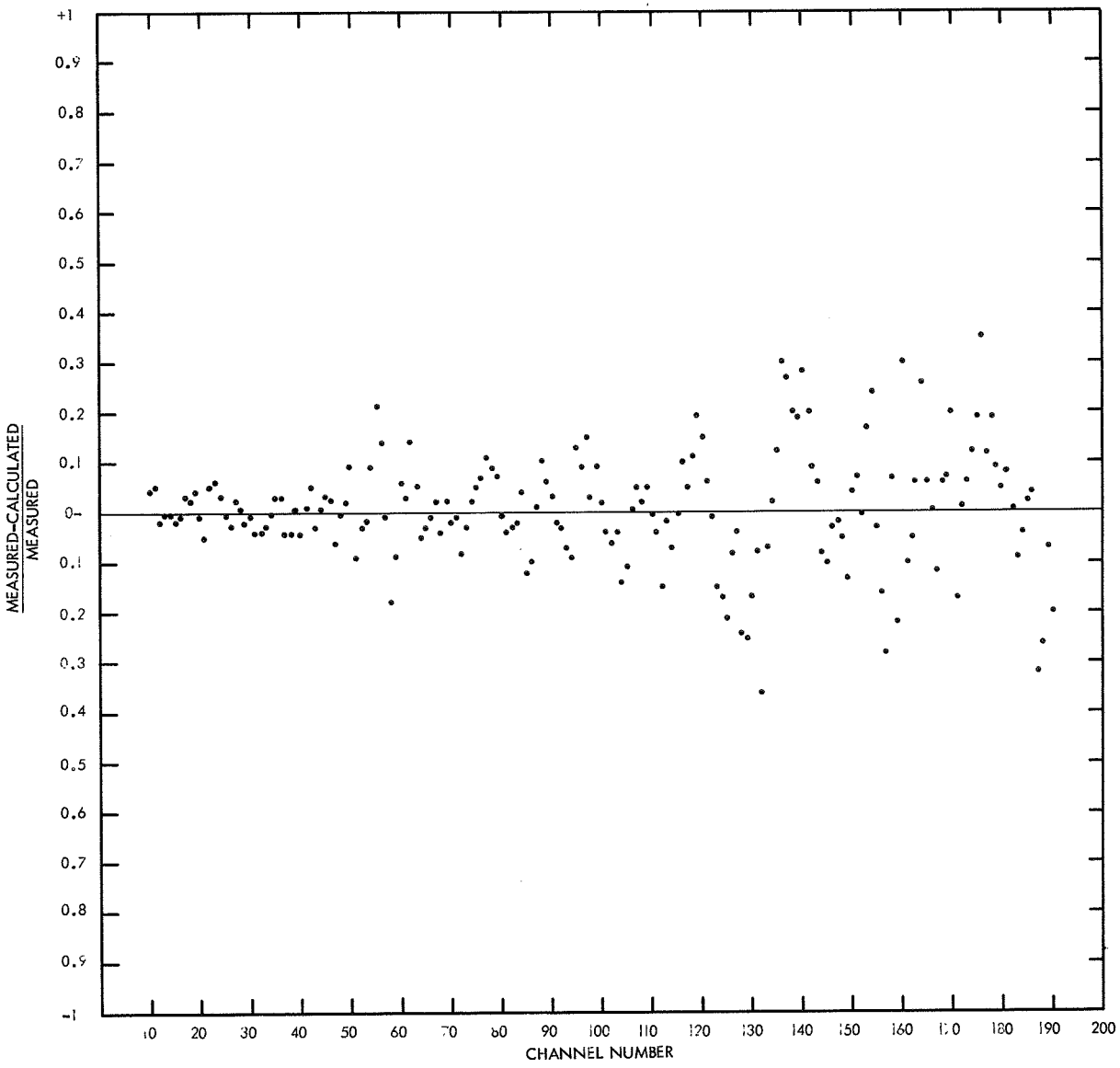
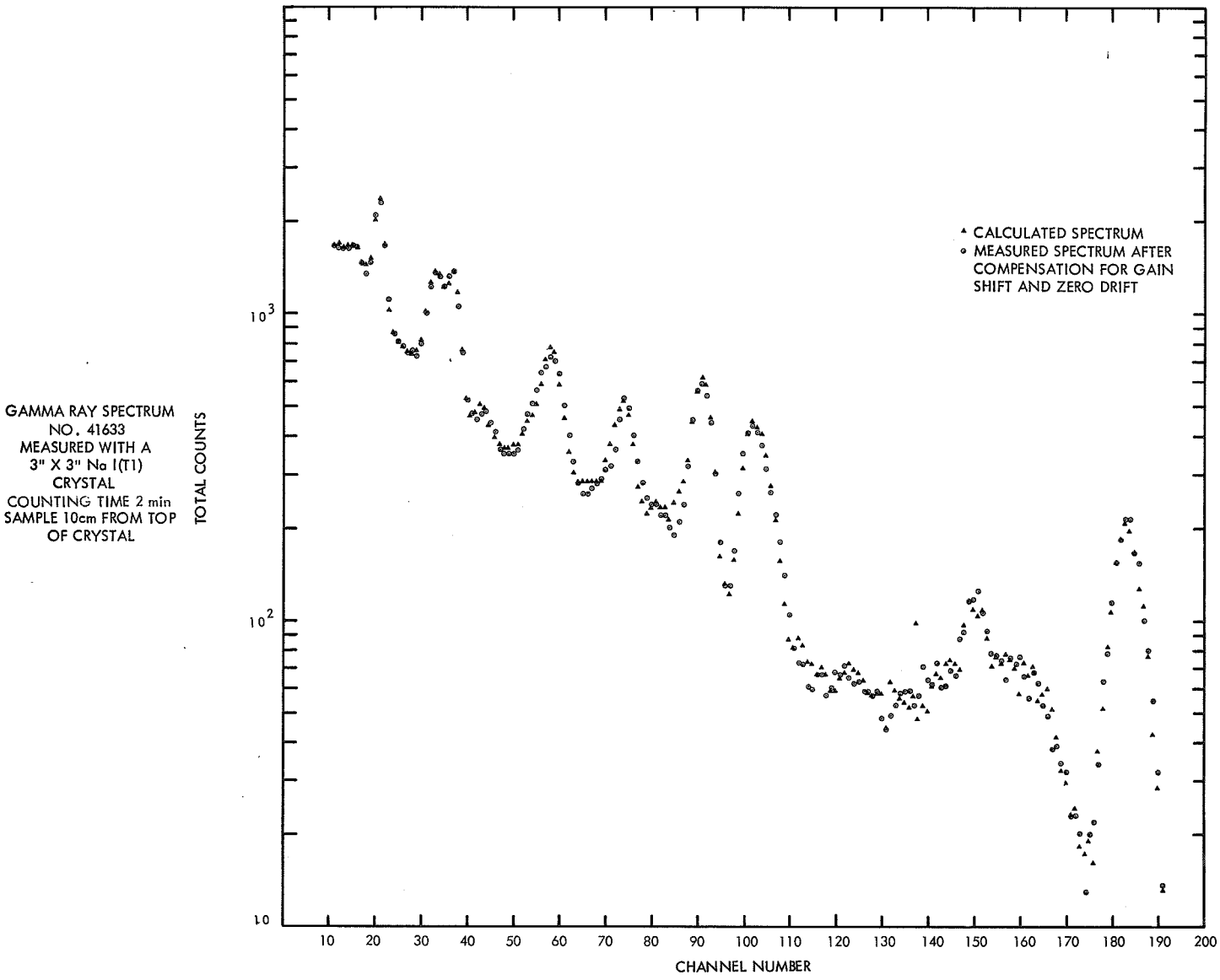


FIGURE 27.—Pulse height spectrum of mixture no. 41259.


GAMMA RAY SPECTRUM
NO. 41633
MEASURED WITH A
3" X 3" Na I(T1)
CRYSTAL
COUNTING TIME 2 min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER
▲ CALCULATED SPECTRUM
○ MEASURED SPECTRUM AFTER
COMPENSATION FOR GAIN
SHIFT AND ZERO DRIFT

DIFFERENCE SPECTRUM

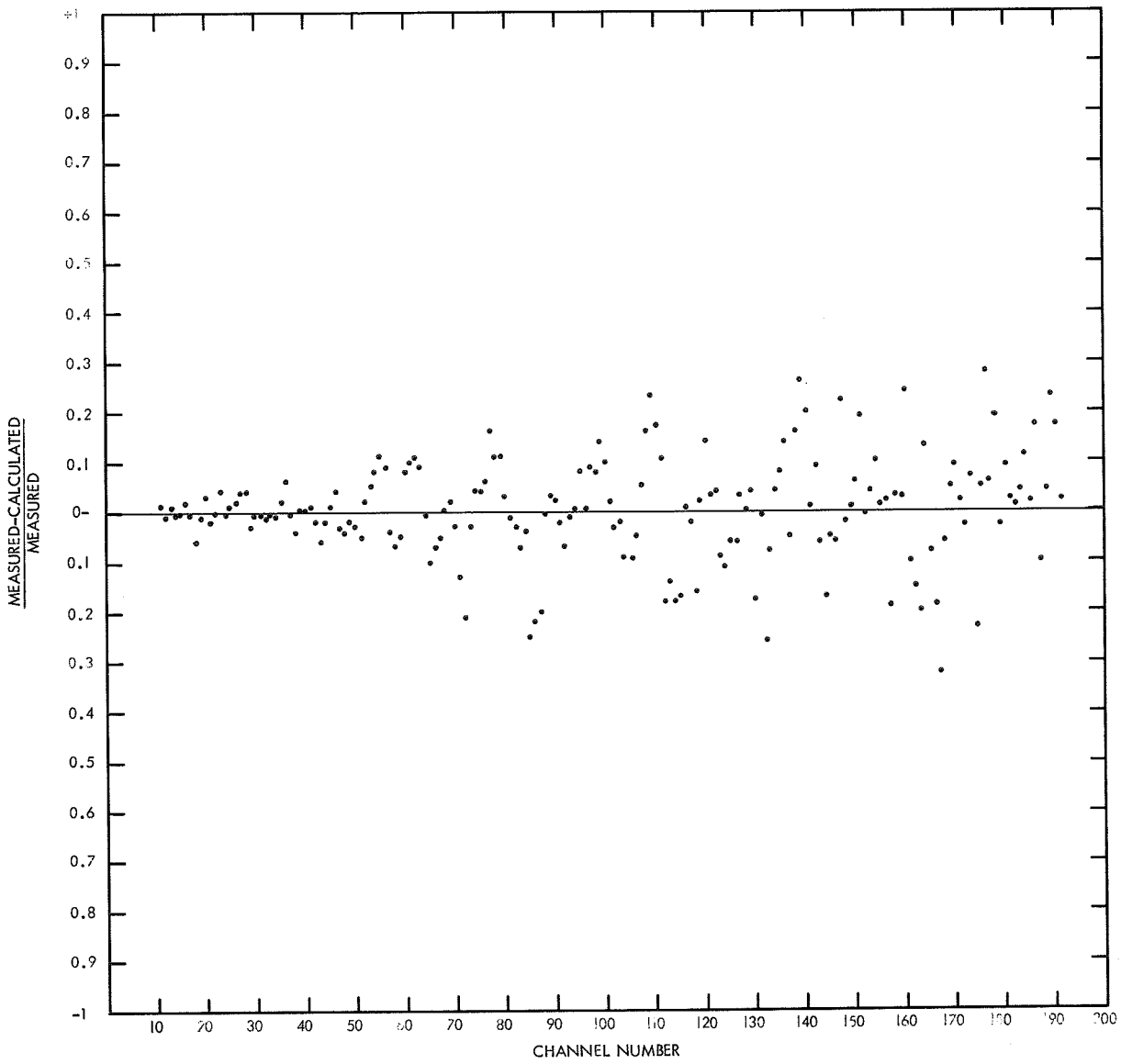
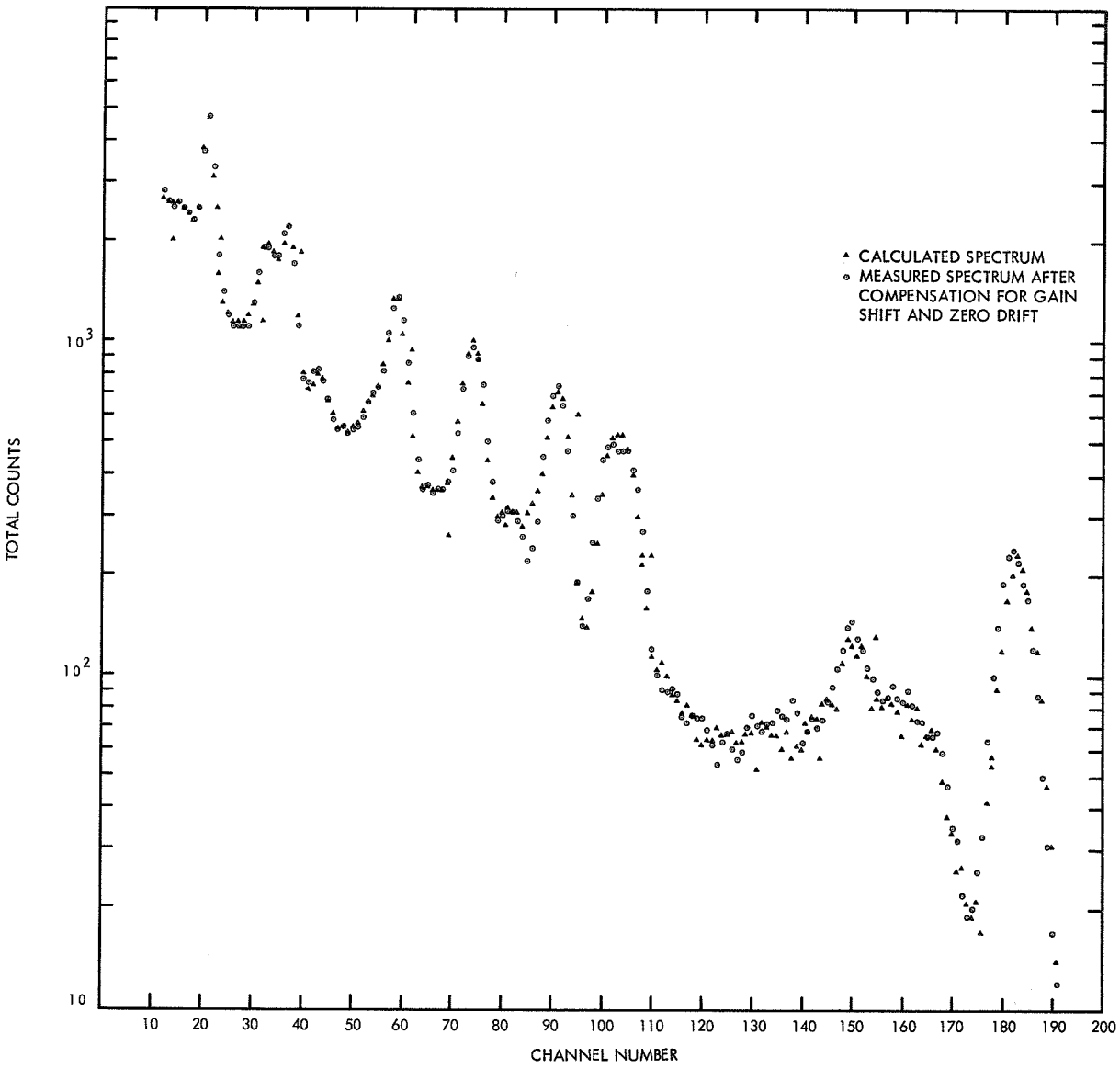


FIGURE 28.—Pulse height spectrum of mixture no. 41633.

GAMMA RAY SPECTRUM
NO. 50827
MEASURED WITH A
3" X 3" Na I(Tl)
CRYSTAL
COUNTING TIME 5 min
SAMPLE 10cm FROM TOP
OF CRYSTAL


TOTAL COUNTS
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER
▲ CALCULATED SPECTRUM
○ MEASURED SPECTRUM AFTER COMPENSATION FOR GAIN SHIFT AND ZERO DRIFT

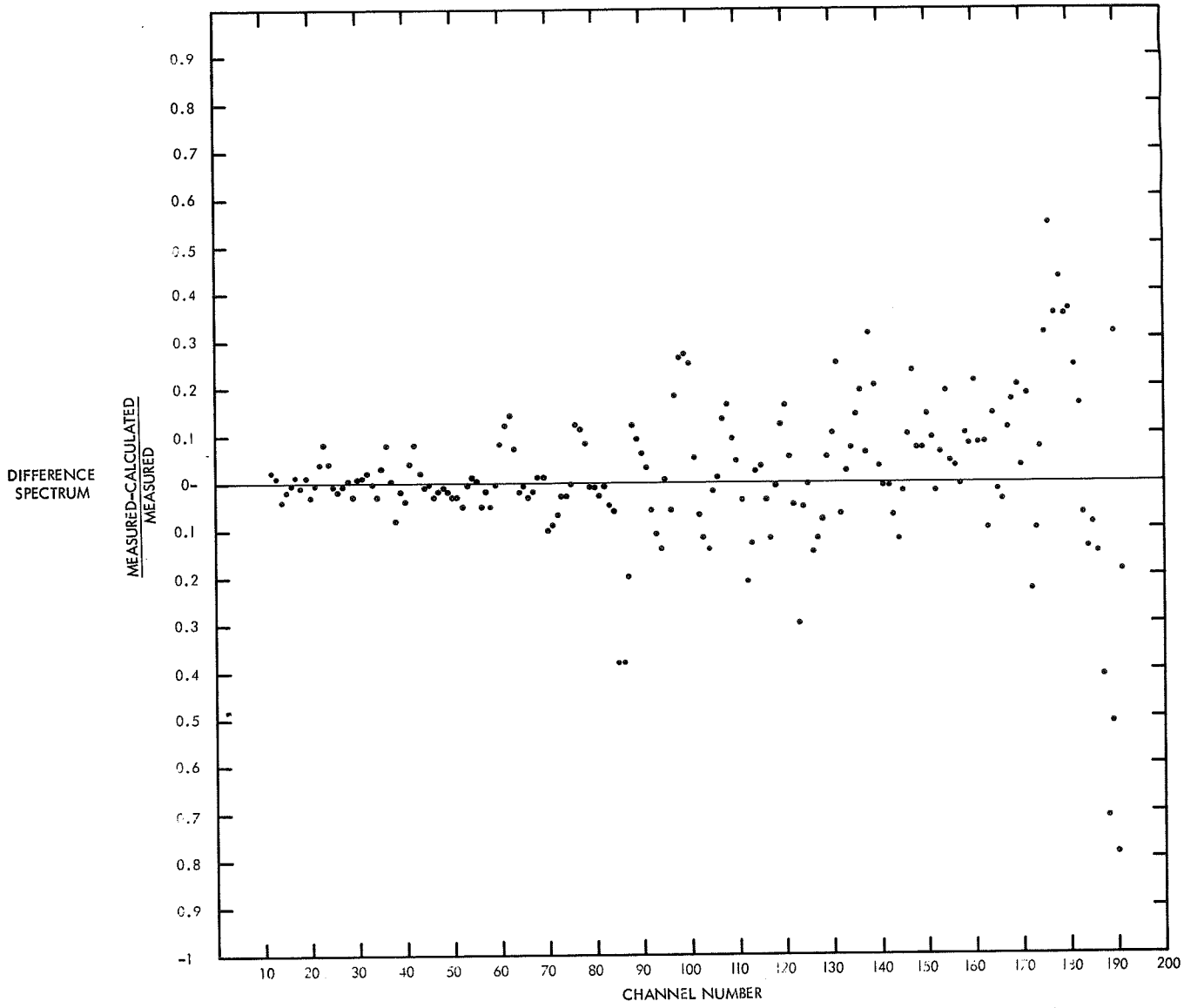
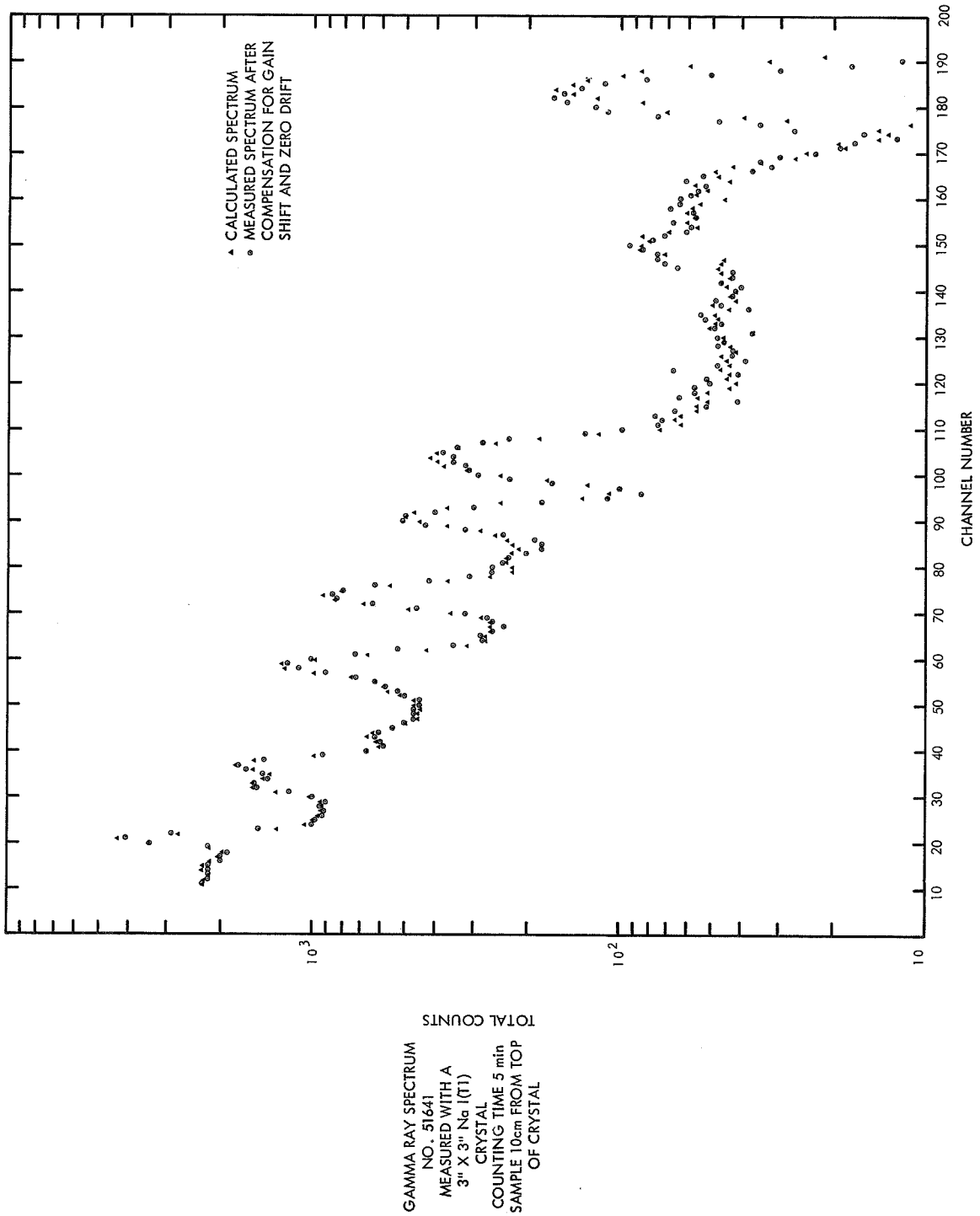


FIGURE 29.—Pulse height spectrum of mixture no. 50827.


▲ CALCULATED SPECTRUM
● MEASURED SPECTRUM AFTER COMPENSATION FOR GAIN SHIFT AND ZERO DRIFT
GAMMA RAY SPECTRUM
NO. 51641
MEASURED WITH A
3" X 3" Na I(Tl)
CRYSTAL
COUNTING TIME 5 min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER

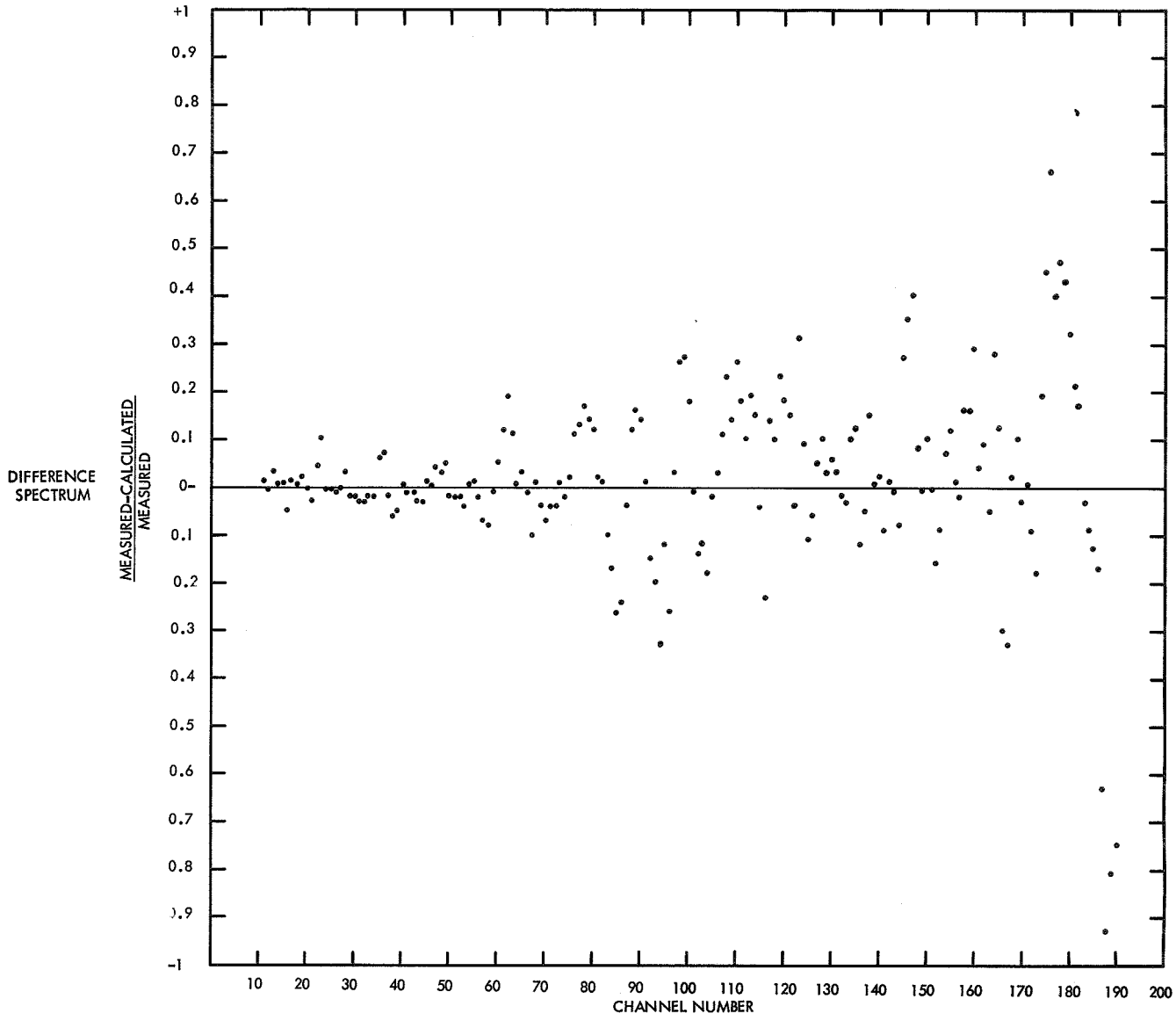
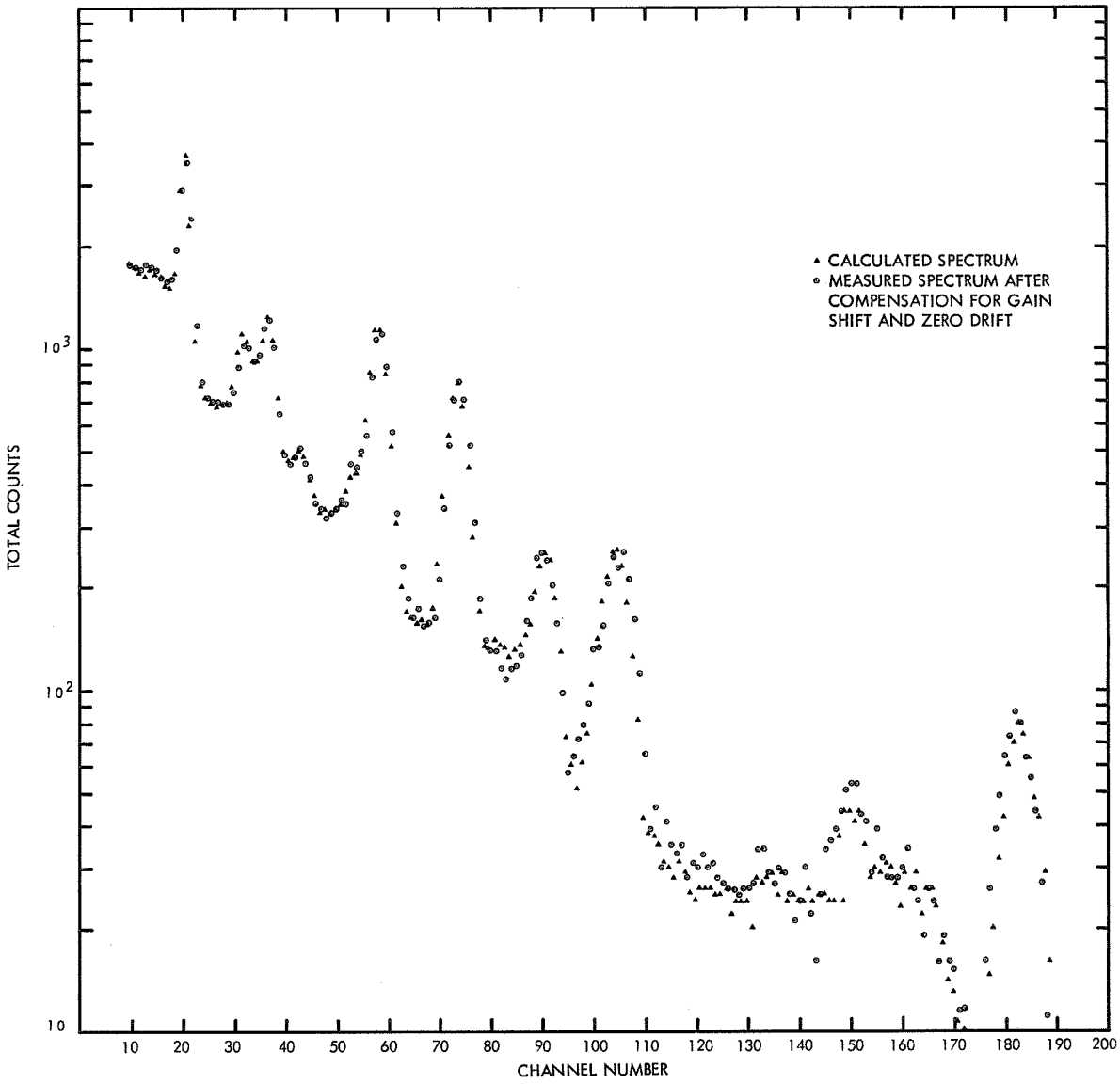


FIGURE 30.—Pulse height spectrum of mixture no. 51641.

GAMMA RAY SPECTRUM
NO. 60900
MEASURED WITH A
3" X 3" Na I(T1)
CRYSTAL
COUNTING TIME 5 min
SAMPLE 10cm FROM TOP
OF CRYSTAL


TOTAL COUNTS
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER
▲ CALCULATED SPECTRUM
○ MEASURED SPECTRUM AFTER COMPENSATION FOR GAIN SHIFT AND ZERO DRIFT

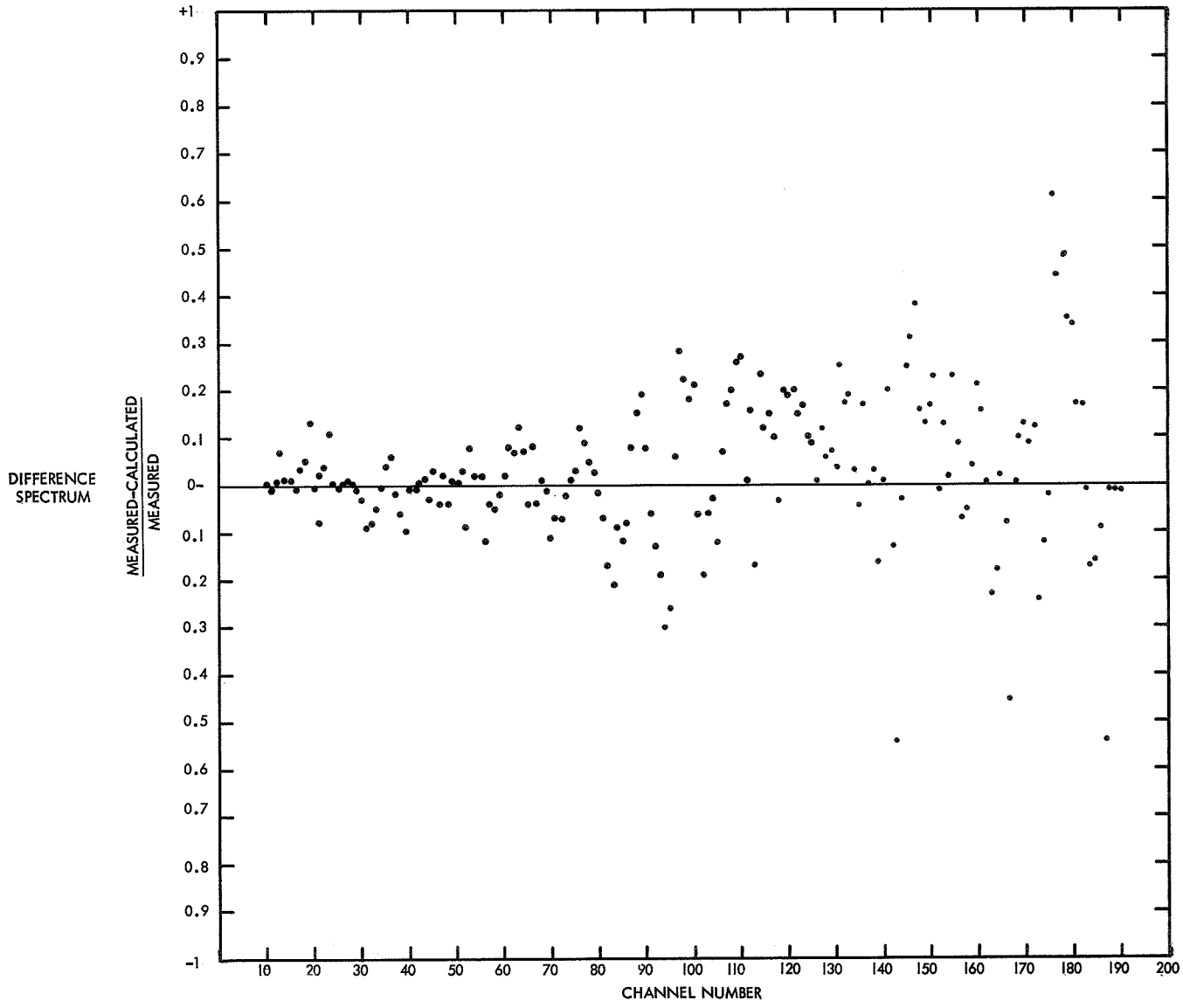
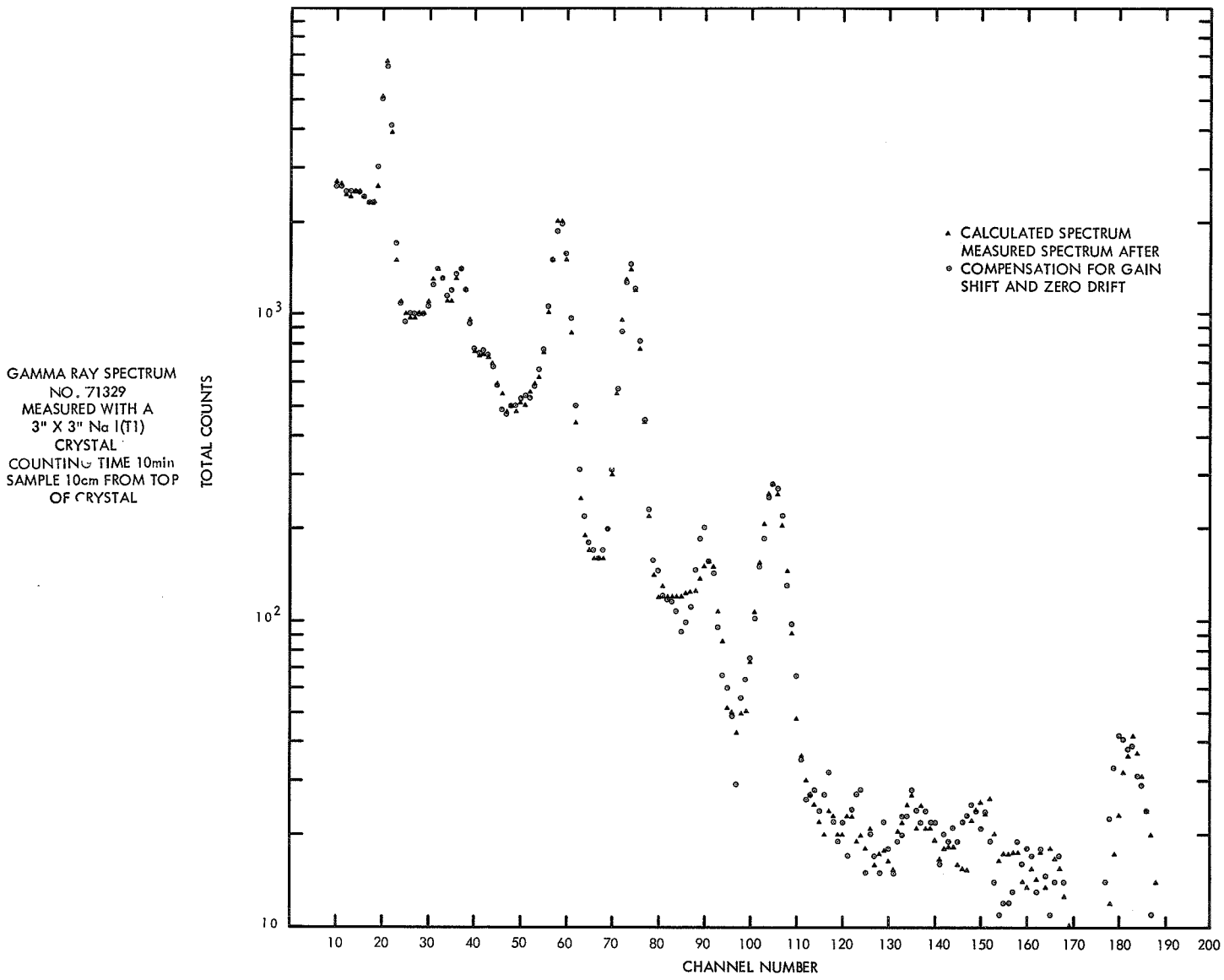


FIGURE 31.—Pulse height spectrum of mixture no. 60900.


GAMMA RAY SPECTRUM
NO. 71329
MEASURED WITH A
3" X 3" Na I(Tl)
CRYSTAL
COUNTING TIME 10min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER
▲ CALCULATED SPECTRUM
MEASURED SPECTRUM AFTER
○ COMPENSATION FOR GAIN
SHIFT AND ZERO DRIFT

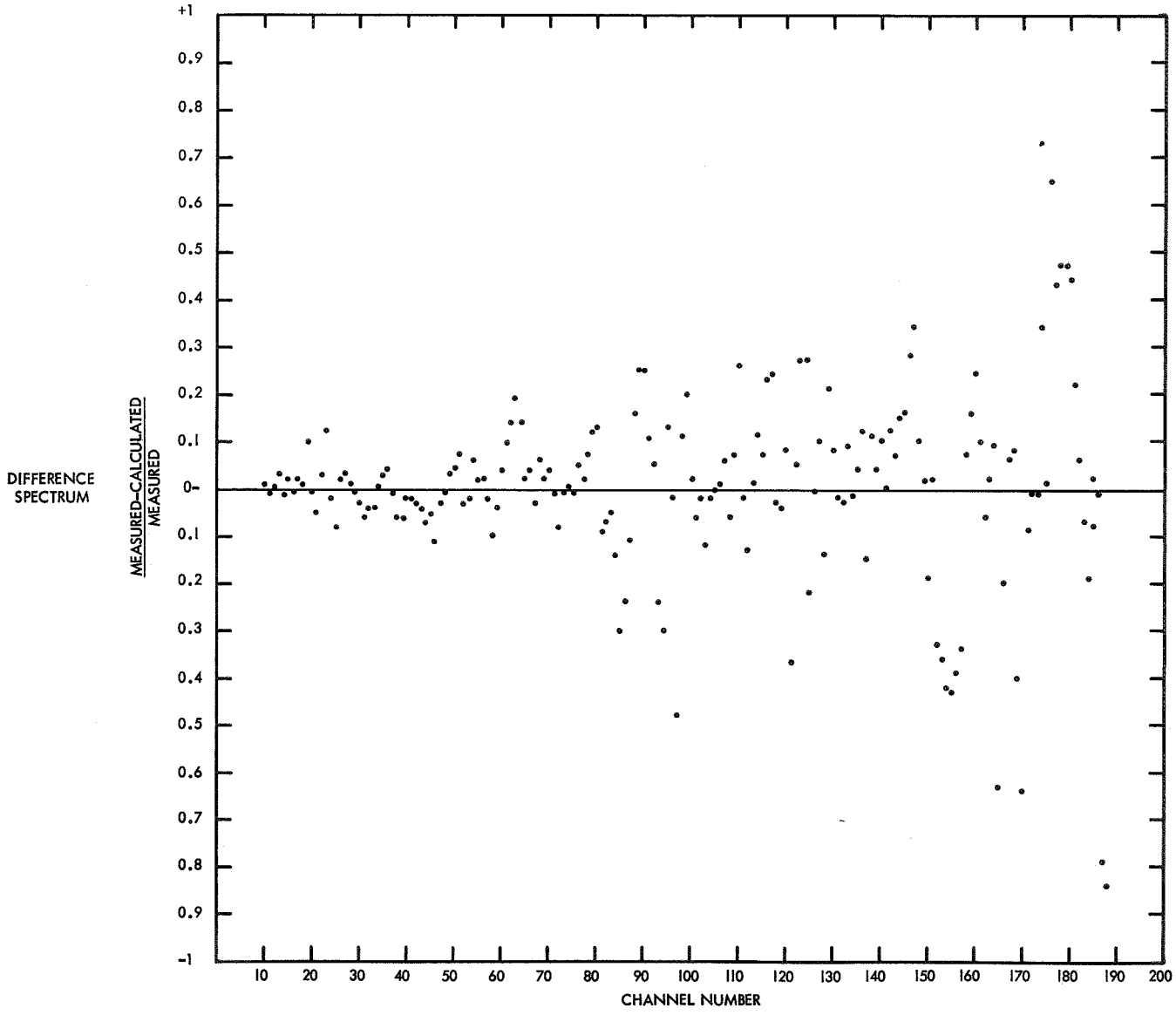
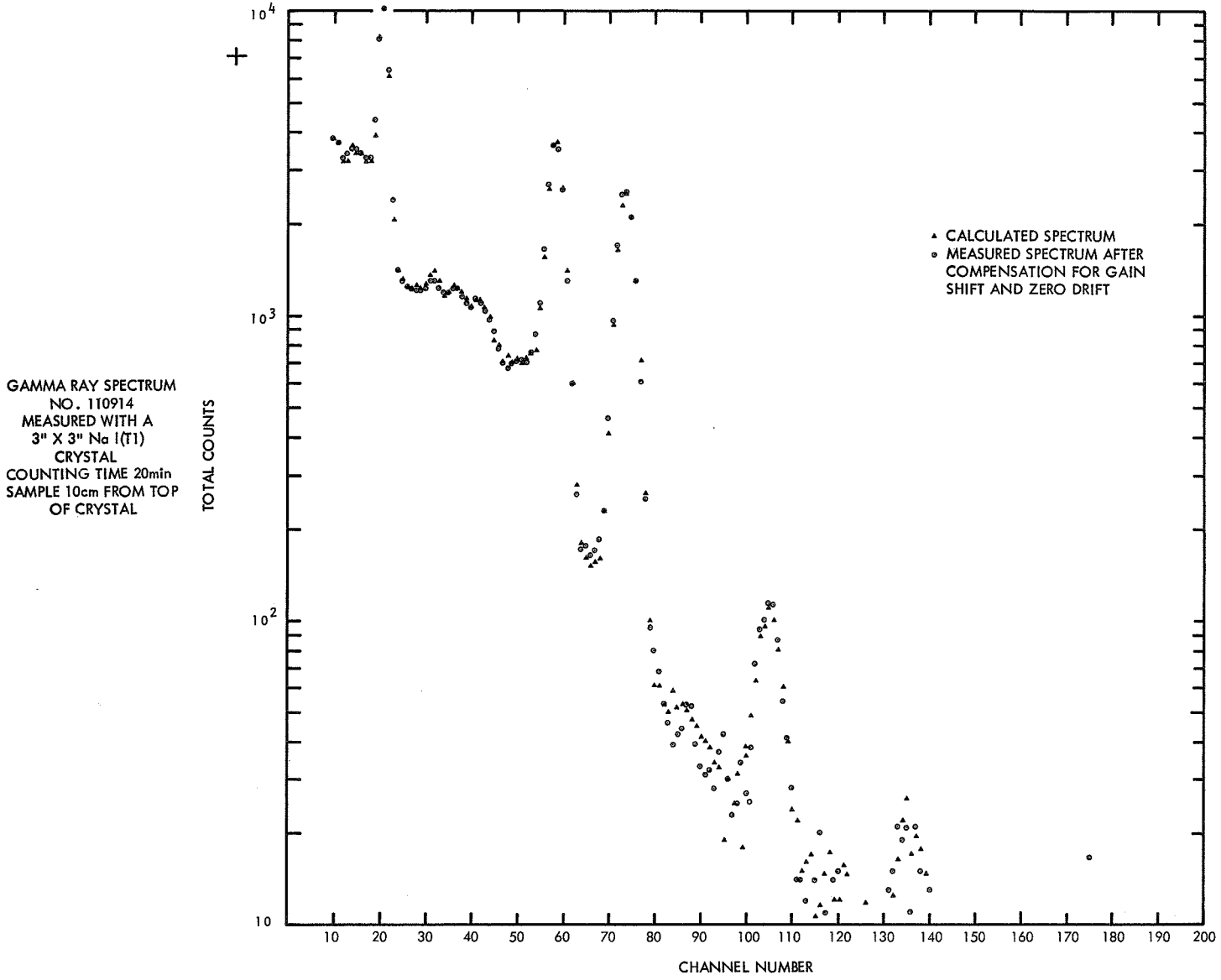


FIGURE 32.—Pulse height spectrum of mixture no. 71329.


GAMMA RAY SPECTRUM
NO. 110914
MEASURED WITH A
3" X 3" Na I(Tl)
CRYSTAL
COUNTING TIME 20min
SAMPLE 10cm FROM TOP
OF CRYSTAL
TOTAL COUNTS
10^4
10^3
10^2
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANNEL NUMBER
▲ CALCULATED SPECTRUM
○ MEASURED SPECTRUM AFTER
COMPENSATION FOR GAIN
SHIFT AND ZERO DRIFT

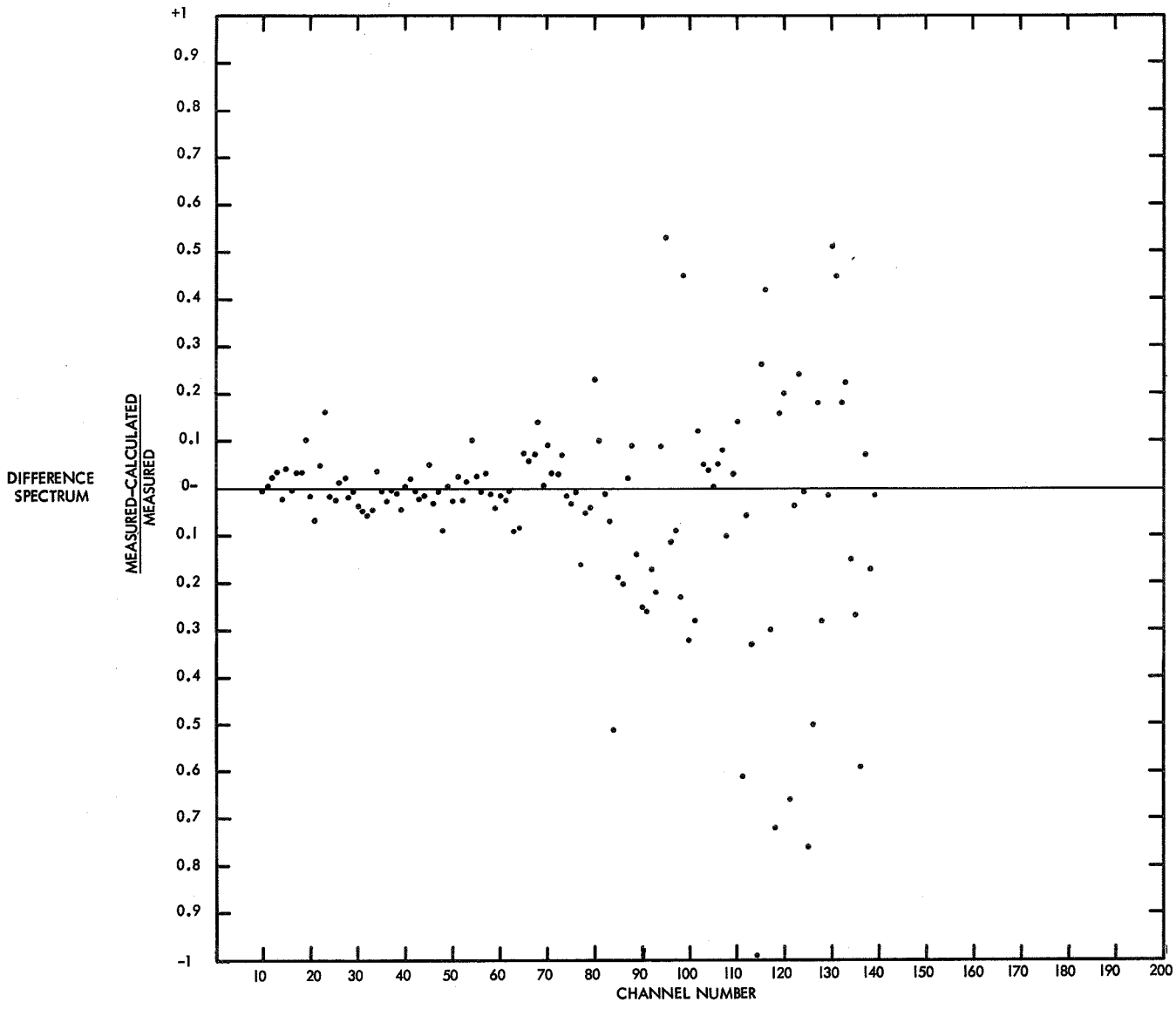


FIGURE 33.—Pulse height spectrum of mixture no. 110914.

Figures 34 through 38 are plots of relative intensities obtained using leastsquares and the nonnegativity criterion as a function of time for Na, Sc, La, As, and I. The solid line is a least-square fit of the significant points to the half-life of the various nuclear species. In the case of the Na, Sc, and La, the first four points were ignored since a number of the shorter half-life components correlated; as can be seen, these points indicate that there is a significant overestimation in the case of La and underestimation in the case of Sc. Na seems relatively unperturbed. The relative intensities for all the time periods for each of these components were obtained from these curves, and their values used for subtracting the Na, Sc, and La components from the measured pulse spectra. The results of the least-square calculations are plotted as functions of time for Cl, Mn, K, Cu, and Cr in Figures 39 through 43. The solid line is the least-square fit to the half-life for each of the nuclear species.

The relative intensities for time zero are obtained for each component from Figures 34 through 43 and can be compared with the standards to obtain a quantitative analysis. The standards were irradiated in the same flux and measured in the same geometry as the mixtures. The results of the calculation are shown in Table 3.

The error shown is the error obtained from counting statistics. The errors due to changes in flux and irradiation time are not included. Furthermore, the Cr standard sample was found to have Na contamination (see Figure

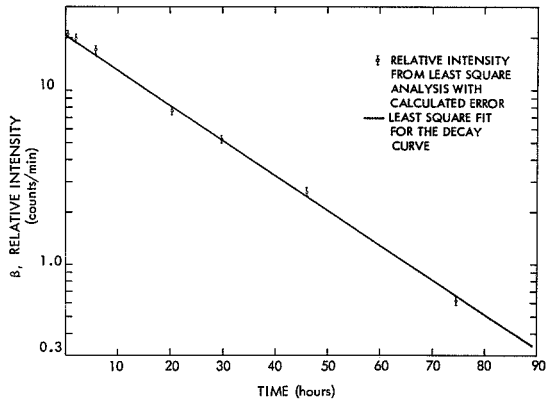

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 34.—Decay curve for Na.[24]

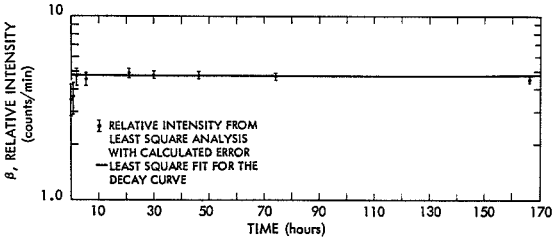

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 35.—Decay curve for Sc.[46]

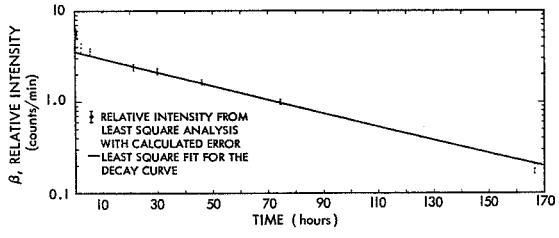

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 36.—Decay curve for La.[140]

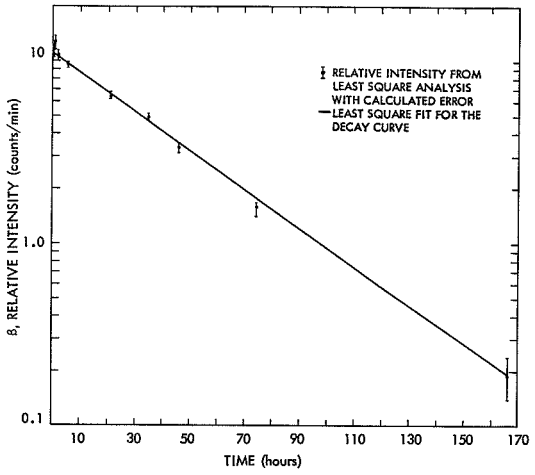

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 37.—Decay curve for As.[67]

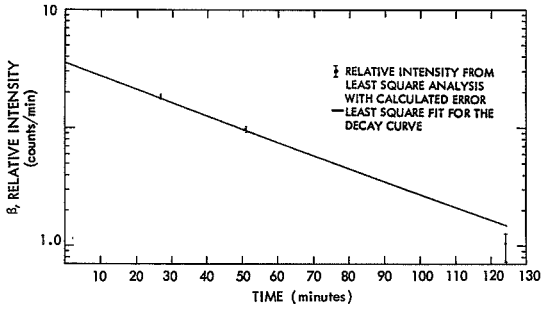

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (minutes)

FIGURE 38.—Decay curve for I.[128]

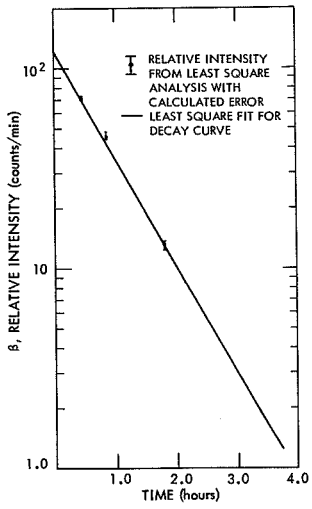

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 39.—Decay curve for Cl.[38]

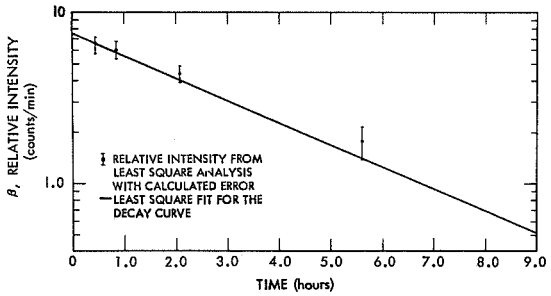

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 40.—Decay curve for Mn.[56]

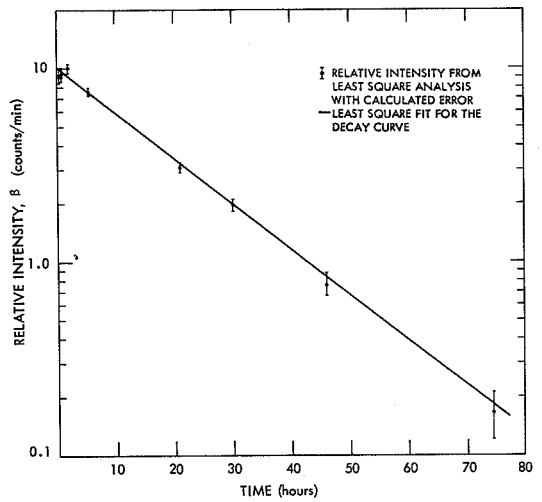

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
RELATIVE INTENSITY, β (counts/min)
TIME (hours)

FIGURE 41.—Decay curve for K.[42]

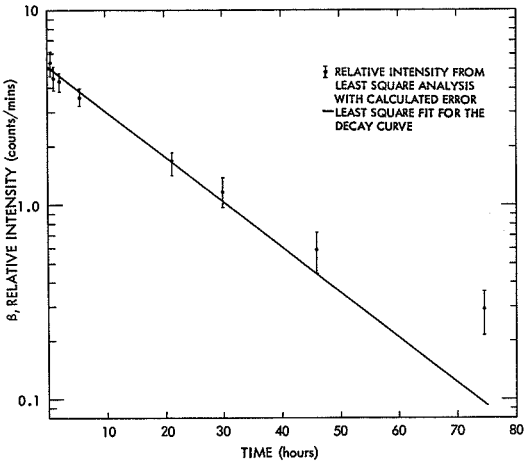

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/mins)
TIME (hours)

FIGURE 42.—Decay curve for Cu.[64]

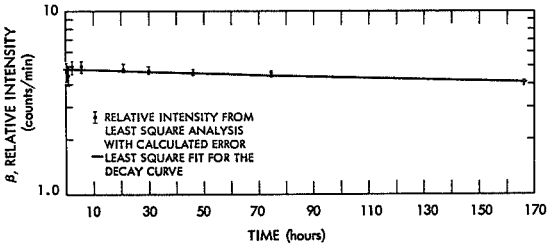

RELATIVE INTENSITY FROM LEAST SQUARE ANALYSIS WITH CALCULATED ERROR
LEAST SQUARE FIT FOR THE DECAY CURVE
β, RELATIVE INTENSITY (counts/min)
TIME (hours)

FIGURE 43.—Decay curve for Cr.[51]

TABLE 3.—*Quantitative and Qualitative Analyses Obtained with Activation Analyses*

Element	Prepared sample	Experimentally* determined by the least-square analysis
Na	5.00 μg	7.8±1.5 μg**
Cl	36.8 μg	39.5±1.5 μg
K	0.404 mg	0.371±0.013 mg
Mn	0.101 μg	0.090±0.008 μg
Sc	14.2 μg	13.6 ±0.4 μg
As	5.00 μg	4.97±0.18 μg
Cu	2.23 μg	2.70±0.21 μg
Cr	1.82 mg	1.77±0.03 mg
I	2.49 μg	2.45±0.12 μg
La	2.29 μg	2.65±0.14 μg

*Errors shown are only those attributed to counting statistics.

**This value seems to be correct because of Na contamination of the Cr standard.

21). Thus the prepared value had to be smaller than the calculated value; from the estimate of the amount of contamination present, it

was found the 7.8 ± 1.5 μg was closer to the true amount. The larger difference between the experimentally determined value and the prepared value may also be attributed to the fact that the standard spectrum obtained required the subtraction of the Na component. This increased the error in the determination of the relative intensity of the Cr component. This measured error is not included in the error calculation presented in Table 3. Furthermore, slight argon contamination had to be subtracted from the Mn, Sc, and I standard spectra. These errors plus the error in obtaining an inversion factor from relative intensity to μg or mg are not included in the error calculation presented in Table 3. With these factors in mind the experimentally determined values seem to agree well with the values used in preparing the unknown sample.

SUMMARY OF RESULTS

A method for obtaining differential elemental spectra from pulse height spectra has been developed. Although an exact solution cannot be obtained, and although the problem is not linear in solution, most probable solutions can be obtained using the linear least-square solution. The solutions obtained by this method agree with the true values in all cases tested (e.g., X-ray and gamma-ray spectroscopy). The technique allows for the calculation of relative intensity, of the statistical variance based on counting statistics of the correlation between library components, and of the goodness of fit chi-square.

In order to obtain a unique solution and nonoscillating-solution, physical constraints are imposed on the solution. In particular, constraints involving the finding of solutions in the positive domain and the use of filters and the use of nuclear decay to eliminate library correlations have been included in the program. These constraints are included as either an iterative search mode for nonnegativity or a component subtraction mode in the computer program.

The problem of nonlinearities in the pulse height scale that can be attributed to gain shift and zero drift has been considered. Both of the search modes to find the proper gain shift and zero drift and the use of constant gain shift and zero drift have been included in the analytic method developed herein. Another mode is available in the program for correcting the pulse height scale of the library function for zero drift and gain shift. In this mode, each component can be separately compensated for so that all the components can be set on a common scale.

Finally the problem of background compensation was considered. A method for background subtraction and the use of the background as a library component in the least-square analysis were considered. There is an option for the use of either method in the computer program developed at the laboratory. Techniques for compensating for background gain shift and zero drift have also been developed and are included in the program. The search mode can be performed in the same range as that for the input of a data spectrum or can be performed in the mode used for correcting the library spectra to a common pulse height scale.

The details of the structure of the computer programs, the FORTRAN statement of the program, data for use in the program, and typical computer outputs are presented in Appendix A.

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APPENDIX A

LINEAR LEAST-SQUARE COMPUTER PROGRAM

R. L. Schmadebeck

J. I. Trombka

The present Linear Least-Square Analysis of Radiation Spectra Program is the fifth generation refinement of a program written by J. I. Trombka in December 1962.* This program was refined and added to by P. L. Poulson† of the Jet Propulsion Laboratory and later by R. Baxter of Goddard Space Flight Center, Greenbelt, Maryland.

The present program is written in the FORTRAN language for use with an IBM 7094 computer. The program is adaptable to almost any computer having a memory of 32 thousand, 36-bit words and a FORTRAN compiler by minor modifications of the formulas and format statements. All data are inputed by magnetic tape which can be fed by a punched card reader. The output is fed to magnetic tape which is then printed out by means of a line printer or punched cards.

All arrays are stored as vectors (i.e., single-dimensioned arrays). The maximum length of the spectra and background arrays is 500 channels of data apiece. The maximum storage size of the library is 40 components by 400 channels, or 32 components by 500 channels, for a total storage of 16,000 words. In order to conserve storage space, most of the arrays are stored in common. Unimportant computational values are stored in the same common location, thus destroying the old values each time a new computation is done.

In addition to the program, one subroutine and seven functions are required. The EXIT subroutine is used to allow the next job on the computer to begin immediately without halting the computer should an error or lack of data be sensed in the present job. This subroutine and the seven internal functions are usually available with the associated FORTRAN library. The seven internal functions required are:

1. Absolute Value ABSF(X)
2. Fixed to Floating Point Conversion FLOAT(X)=INT(X)
3. Floating to Fixed Point Conversion INT(X)=FLOAT(X)
4. Maximum XMAX0F(A, B)
5. Minimum XMIN0F(A, B)
6. Modulo XMODF(L, 2)
7. Square Root SQRTF(A)

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*J. I. Trombka, "Least-Square Analysis of Gamma-Ray Pulse Height Spectra," Technical Report No. 32–373, Jet Propulsion Laboratory, Pasadena, California, December 1962.

†P. L. Poulson, and R. E. Parker, Computer Program Report: "Linear Least-Squares Analysis of Radiation Spectra, "Inter-office Memorandum, Jet Propulsion Laboratory, Pasadena, California, March 31, 1965.

PROGRAM STRUCTURE

The program consists of a main portion and 12 subroutines. The 12 subroutines are:

1. Flow 1
2. Flow 2
3. Flow 3
4. PickG
5. Shift
6. Drift
7. Store
8. Least
9. SumDiv.
10. Invert
11. Mult.
12. Corr.

Each of these subroutines will be discussed in detail in the following sections. A flow diagram of the whole program has already been illustrated in the main body of the report.

The program will now be explained in the order of occurrence of the routines. Since Flow 1 is entered from Flow 2, Flow 2 will be discussed before Flow 1.

MAIN PROGRAM

The main program is the beginning and end point of the Linear Least-Square Program. The library is read into the "A" matrix component by component. In front of each component is a card with a 6-character identification (e.g., Mn 54) which is stored as ALABL(I) for future identification of the component. The input cards shown in Figure A–1 are as follows:

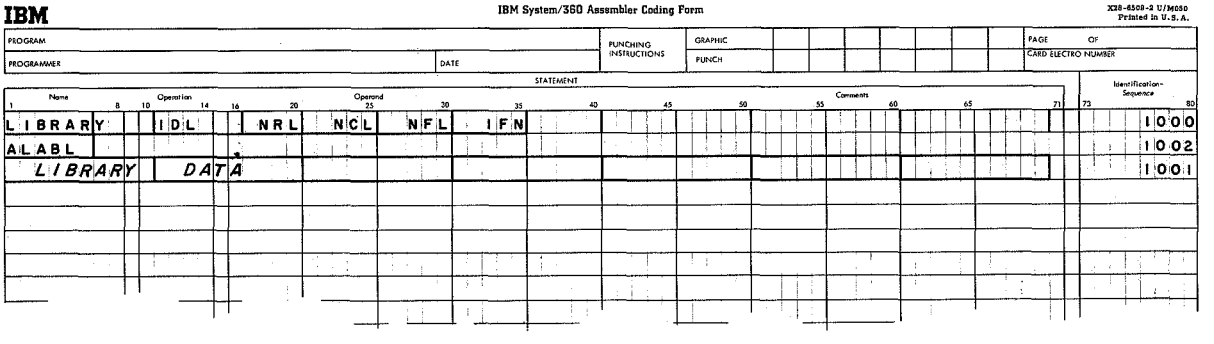


FIGURE A–1.—Library input card format.

1. *Library Control Card—1000 FORMAT* (A6, 4X, A6, I4, 4I5, 3F10.0)
   a. Field 1 must contain the characters LIBRAR or an error statement will be written, and an exit from the program executed.
   b. Field 2 is ignored. It may be used to extend field 1.
   c. Field 3 contains a 6-character identification code (IDL) which the experimenter may wish to assign to the library (e.g., X-Ray 3). If the IDL equals LAST (left adjusted), the last half of the "A" matrix will be read into the first half of the "A" matrix. This allows the user to enter Flow 3, perform a library preparation, and then use the unprepared library for analysis without resubmitting the data to the computer.
   d. Field 4 specifies the number of data points in each library component (NRL).

e. Field 5 specifies the number of components in the library (NCL).

f. Field 6 specifies the channel number (NFL) of the first data point of each library component.

g. Field 7 contains a key used only in Flow 3 (IFN). The key specifies whether the library being punched out from memory will be normalized to one (i.e., IFN=1) or whether it will be punched out exactly as in memory.

2. *Component Card—1002 FORMAT* (A6)

Field 1 specifies a 6-character identification code which is associated with the data that follow that card.

3. *Data Cards—1001 FORMAT* (7F10.0)

Fields 1 through 7 contain the data to be read into the library. There must be the exact quantity of numbers as specified by (NRL). Zeroes may be filled in by blanks on the cards.

After the library has been stored in the "A" matrix, the spectrum which is to be analyzed is either read from the appropriate place into RHO or a new spectrum is read into RHO. The input cards shown in Figure A–2 are as follows:

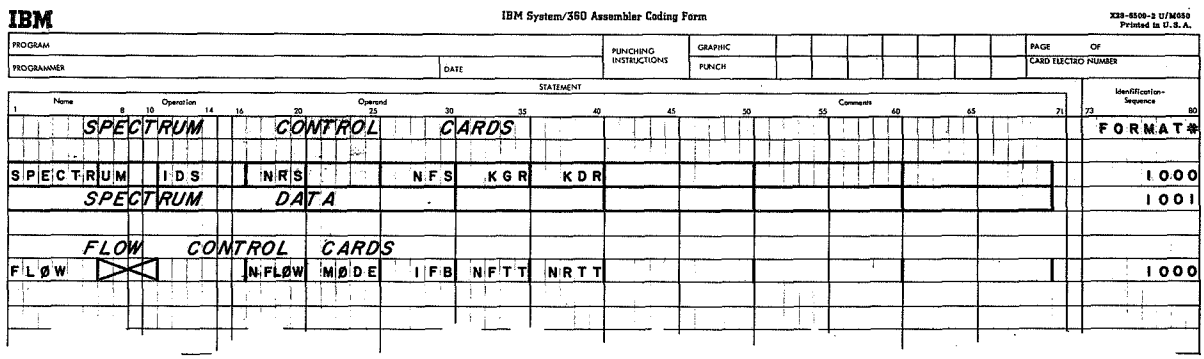


FIGURE A–2.—Spectrum and flow control card format.

4. *Spectrum Card—1000 FORMAT* (A6, 4X, A6, I4, 4I5, 3F10.0)

a. Field 1 must contain the characters SPECTR, or an error statement will be written and an exit from the program executed.

b. Field 2 is ignored and may be used to extend field 1.

c. Field 3 is a 6-character identification (IDS) which the experimenter may use to identify the spectrum being analyzed. If the IDS is equal to SAME (left adjusted) the spectrum stored in RHO for the previous analysis will be used again. This allows the user to change his limits of analysis without having to reread the RHO data into memory.

If the IDS is equal to LAST (left adjusted) the data stored in the R vector by Flow 2 is read into the RHO vector. The first two channels of the S vector contain the data NRS and NFS and over-ride fields 4 and 6 of the spectrum card. LAST is used to read data which has been background subtracted, gain-shifted, and zero-drifted into Flow 1 for the spectrum stripping.

If the IDS is other than the two previously mentioned, the program requires that a spectrum be read into the RHO vector from the magnetic tape.

d. Field 4 specifies the number of data points (NRS) to be read into memory.

e. Field 5 is ignored.

f. Field 6 specifies the channel number of the first data point being read into RHO (NFS).

g. Field 7 is a key to the gain-shifting (KGR) of the spectrum being analyzed.

KGR=−1	constant gain shift of the spectrum
0	no gain shift of the spectrum
+1	search of the spectrum for gain shift

h. Field 8 is a key to the zero-drifting of the spectrum (KDR).

KDR=−1	constant zero drift of the spectrum
0	no zero drift of the spectrum
+1	search for zero drift of the spectrum

5. *Input Data Cards—1001 FORMAT* (7F10.0)
   a. Fields 1 to 7 contain the data to be read into the RHO vector. There must be the exact quantity of numbers as specified by NRS.

Following the storing of the spectrum for analysis, a flow control card (Figure A–2) is read to initiate the analysis of the spectrum.

6. *Flow Control Card—1000 FORMAT* (A6, 4X, A6, I4, 4I5, 3F10.0)
   a. Field 1 must contain the characters FLOW (left adjusted) or an error statement will be written and an exit executed.
   b. Fields 2 and 3 are ignored by the computer.
   c. Field 4 designates the number of the flow subroutine (NFLOW) which is to be executed. The numbers of the flows are 1, 2, or 3. Any other numbers will cause an error to be diagnosed by the computer and an exit executed. Flow 1 is a spectrum stripping subroutine. Flow 2 is the general flow in which the spectrum can have the background subtracted, the gain shifted, or the zero channel drifted. Flow 3 is a library preparation subroutine.
   d. Field 5 (MODE) specifies the iteration mode option. If MODE=0, negative intensities will be allowed in the analysis. If MODE=1, the negative intensities will be set equal to zero.
   e. Field 6 contains the key (IFB) for analysis of the spectrum regarding the background. There exist three options in specifying background.
      (1) IFB=0, no background will be given.
      (2) IFB=1, background will be subtracted from the spectrum. A background control card will be expected later.
      (3) IFB=−1, the background will be stored after shifting and/or drifting as the last component of the library for analysis. A background control card will be expected later.
   f. Field 7 contains the number of the first channel (NFTT) to be analyzed by the program.
   g. Field 8 contains the last channel number (NRTT) which will be analyzed. Fields 7 and 8 allow the user to break the spectrum up into increments for analysis instead of having to look at the whole spectrum. The chi square value is computed for only the increment between NFTT and NRTT. If NRTT is not read into the computer (i.e., NRTT=0 or minus) the limits of analysis are set as those of the spectrum.

The program now proceeds to the flow specified by the flow control card. After the analysis has been completed, the subroutine returns control to the main program which then begins to search for more spectra for analysis. The computer reads the next control card. If this card contains SPECTR the control passes to the above portion and the analysis begins again. If the card contains FLOW, the program begins the analysis from the point of the FLOW control card. If the card contains LIBRAR, a new library is read into the memory. If the card contains none of the three,the computer assumes that there are no more data, and an EXIT is executed.

FLOW 2

Flow 2 enables the experimenter to perform either a fixed or searching gain shift and zero drift, if necessary, and to either subtract or store as a library component a background spectrum which may or may not have been gain-shifted or zero-drifted. Statistical weight is calculated in the program and least-square analysis performed. A chi square value is calculated and used to find the best possible fit during gain shift and zero drift searches. Since Flow 2 is very complex, only the reduced flow diagram is shown in Figure A–3. A correlation matrix is also calculated and

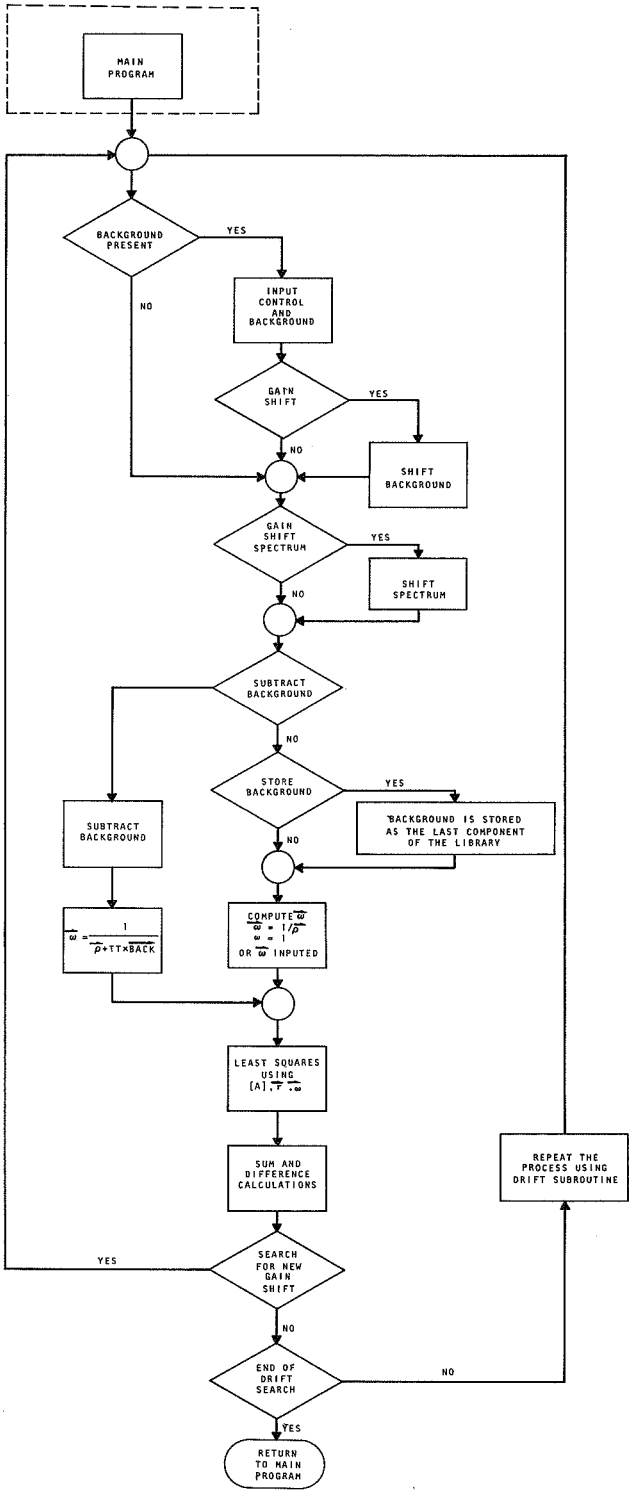


FIGURE A–3.—Reduced flow 2 diagram.

printed out during the analysis. Flow 2 is generally used as an entry point into the spectrum stripping subroutine (Flow 1).

When Flow 2 is called from the main program, the following variables are transferred to Flow 2: NRL, NCL, NFL, NRR, NFR, MODE, KGR, KDR, IFB, NFTT, and NRTT. Except for NRR and NFR, these were all discussed in the main program. NFR and NRR replace NFS and NRS, respectively, so that NFS and NRS can be saved in case the spectrum stored in RHO should be required again.

The RHO vector remains unchanged during analysis and is changed only when a new analysis is started. DRR is a vector where the final gain-shifted spectrum is stored for use with the DRIFT subroutine. DRR remains unchanged during the drift search operation. Each resultant shifted or drifted spectrum is stored in R. BACK, DACK, and ZACK perform the same functions, respectively, for the background as RHO, DRR, and R do for the spectrum. The calculated intensities of the individual components are stored as the BETA vector. The vector LIMIT contains the key to each intensity of the individual components. If LIMIT=1, the component is used in the analysis. If LIMIT=0, the component is disregarded for analysis. The vector OMEGA is the statistical weighting matrix.

The input control cards of Flow 2 are dependent upon the operations to be performed and those previously performed. They will be listed in the order in which they might be found in the case where all are present. In many cases, some of these cards will be missing. It is important that the function of each card is noted, as the omission or addition of any one card will cause the program to malfunction. Figure A–4 shows the cards as described below.

1. *Background Control Card—(1000 FORMAT)* (A6, 4X, A6, I4, 4I5, 3F10.0)

This card must be present if IFB is not equal to zero.

a. Field 1 must contain the characters BACKGR, or an error statement will be written and the program terminated.
b. Field 2 is ignored and may be used to extend field 1.
c. Field 3 may be any 6-character identification code (IDB) that the user desires. If IDB= SAME (left adjusted), the computer will use the background previously stored in BACK. If IDB is not equal to SAME, the computer will expect a background spectrum to be read into memory starting with the next card.
d. Field 4 contains the number of data points (NRB) in the background vector.
e. Field 5 is ignored.
f. Field 6 specifies the channel number of the first data point (NFB) of the background.
g. Field 7 contains the key (KGB) to the shifting of the background.

KGB=−1 background shifted by a constant value
0 no shift of background
+1 gain shift search of background

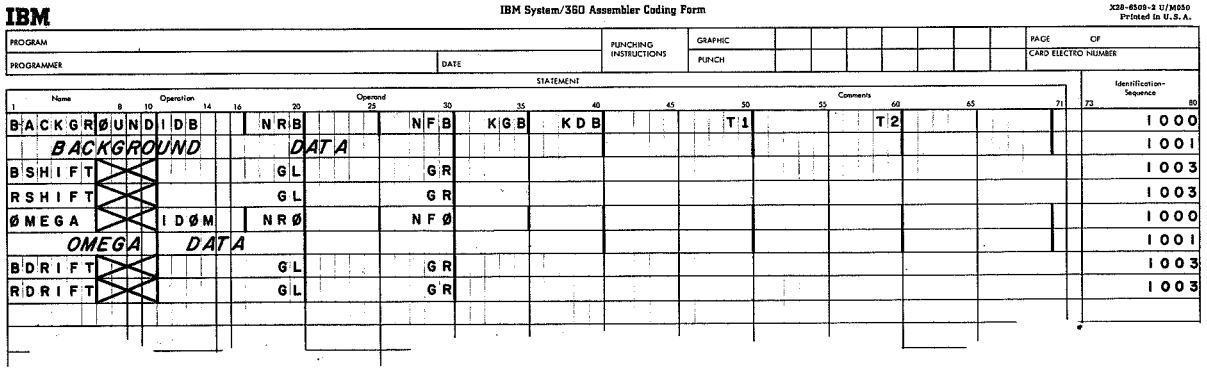


FIGURE A–4.—Flow 2 control card format.

h. Field 8 contains the key (KDB) for zero drift search of the background.

KDB = −1 constant zero drift of background
0 no zero drift of background
+1 zero drift search of background

i. Fields 9 and 10 contain the amount of time for which the spectrum was counted (T1) and the amount of time for which the background was counted (T2). These two values are used to give a multiplication factor for the background to place it on the same time scale as the spectrum RHO.

2. *Background Data Card—(1001 FORMAT)* (7F10.0)

Fields 1 to 7 contain data points to be read into the BACK vector. These cards are not present if IFB equals zero.

3. *Background Shift Card—(1003 FORMAT)* (A6, 4X, 2F10.0)

This card is not present when IFB=0 or KGB=0.

a. Field 1 must contain the characters BSHIFT, or an error statement will be written and an exit from the program executed.
b. Field 2 is ignored.
c. Field 3 contains the value of the left gain-shift limit (GL) to be used for background gain-shift search. If KGB=−1, the value of GL is used as a constant multiplier, and field 4 is ignored.
d. Field 4 contains the right-hand search limit on the background gain shift. Note that the values in fields 3 and 4 must be the same as those of the spectrum if a gain search of the spectrum is performed (i.e., if KGR=+1).

4. *Spectrum Shift Card—1003 FORMAT* (A6, 4X, 2F10.0)

This card is not present when KGR=0.

a. Field 1 must contain the characters RSHIFT, or an error statement will be written and an exit from the program executed.
b. Field 2 is ignored.
c. Field 3 contains the left limit of the spectrum gain-shift search (GL). If KGR = −1, GL is used as a constant multiplier on the spectrum, and field 4 is ignored.
d. Field 4 contains the right limit of the spectrum gain-shift search (GR).

5. *OMEGA Control Card—1000 FORMAT* (A6, 4X, A6, I4, 4I5, 3F10.0)

This card is omitted when the background is subtracted from the spectrum (i.e., IFB=+1), since the OMEGA calculation is done by the program.

a. Field 1 must contain the characters OMEGA (left adjusted).
b. Field 2 is ignored.
c. Field 3 contains the identification code for OMEGA. If IDOM is equal to UNITY (left adjusted), OMEGA is set equal to one. If IDOM is equal to SAME (left adjusted), the OMEGA used for the previous spectrum is used. If IDOM is not equal to either of these, the value of OMEGA is set equal to 1/SPECTRUM.
d. Field 4 specifies the number of data points in the OMEGA vector (NRO).
e. Field 5 is ignored.
f. Field 6 specifies the first channel number of the OMEGA vector to be read into memory (NFO). This field is left blank unless the OMEGA is to be read in from the magnetic tape.

6. *OMEGA Data Card—1001 FORMAT* (7F10.0)

Fields 1 to 7 contain data points of the OMEGA vector which is to be read into memory.

7. *Background Drift Card—1003 FORMAT* (A6, 4X, 2F10.0)

This card is omitted if IFB=0, or KDB=0.

a. Field 1 must contain the characters BDRIFT, or an error statement will be written out and the program terminated.
b. Field 2 is ignored.

c. Field 3 specifies the left background zero drift search limit (GL). If KDB=−1, this value is used as a constant zero drift multiplier, and field 4 is ignored.

d. Field 4 specifies the right background zero drift search limit (GR).

The values given in fields 3 and 4 must equal those used for the spectrum drift limits if KDR=+1 also.

8. *Spectrum Drift Card—1003 FORMAT* (A6, 4X, 2F10.0)

This card is omitted if KDR=0.

a. Field 1 must contain the characters RDRIFT, or an error statement will be written and the program terminated.

b. Field 2 ls ignored.

c. Field 3 specifies the left spectrum zero drift search limit (GL). If KDR=−1, this value is used as a constant zero drift multiplier, and field 4 is ignored.

d. Field 4 specifies the right limit of the spectrum zero-drift search (GR).

The important variables not already mentioned will be discussed and their function in the program listed.

1. G is the gain-shift or zero-drift factor picked by the PICKG subroutine and fed to the SHIFT or DRIFT subroutine depending on whether the program is performing a shift or drift iteration.

2. JFK is the key used in the PICKG subroutine and discussed in detail under that section.

3. J is a key used to define the number of library components being used in the analysis of a spectrum.

4. LFB and LFR are storage locations for the first channel number of the shifted background and RHO spectra after they have been gain-shifted and stored in DACK and DRR, respectively.

5. LRB and LRR are storage locations for the number of data points of DACK and DRR, respectively, after they have received the last gain-shifted spectra.

6. MFB, MFR, MRB, and MRR are storage locations for the values of NFB, NFR, NRB and NRR after they have been shifted or drifted by a factor of G.

7. MLAP and NLAP are the lowest and highest channels of analysis, respectively. They are used to limit the analysis to only those channels which have data stored in the spectrum, background, and library.

8. NEWG is a key used to designate the last iteration in the gain-shift or zero-drift search. NEWG is kept equal to 0 during searching but is set equal to 1 when the iteration is made for the last time. This causes the final data to be read out onto tape.

9. NOMG is a key to the calculation of the statistical weight matrix OMEGA.

a. NOMG=1 signifies that the OMEGA vector is to be read into the memory from punched cards.

b. NOMG=2 sets the OMEGA vector to 1.0 for all channels.

c. NOMG=3 keeps the OMEGA vector as previously calculated.

d. NOMG=4 sets the OMEGA vector equal to 1/RHO.

NOTE: NOMG is not used when the background is subtracted from the spectrum in Flow 2 (i.e., IFB=1).

10. NFO and NRO are the number of the first channel and the number of data points, respectively, of the OMEGA vector.

11. NROUT is a key to the shifting and drifting portion of the program. If NROUT equals −1 or 0, only those operations in the shift portion of the program will be executed. If NROUT equals +1, the drift portion will be executed.

12. TOTAL is the storage location for the value of chi square computed in the SUMDIV subroutine.

Flow 2 requires subroutines (1) PICKG, (2) SHIFT, (3) DRIFT, (4) STORE, (5) LEAST, (6) SUMDIV, (7) INVERT, (8) MULT, and (9) CORR, along with the main program for the complete analysis of a spectrum.

FLOW 1

Flow 1 (shown in Figure A–5), is essentially a spectrum stripping program allowing individual components of the library to be subtracted from a spectrum and a least-square analysis to be performed on the reduced spectrum. Flow 1 is entered through Flow 2. The shifting, drifting, and background are handled by Flow 2, and the resultant spectrum is stored in the R matrix by Flow 2. Control is then returned to the main program. The spectrum card contains the characters LAST in field 3, which causes the spectrum from R to be stored as the RHO component. Since Flow 1 does not shift, drift, or work with background, these fields can be omitted on the control cards and are ignored by the program if they are present. The variables transferred to Flow 1 from the main program are NRL, NCL, NFL, NRR, NFR, and MODE. These variables have been previously defined. The intensity and error must be known for each component which is to be subtracted from the spectrum. A least-square analysis is then performed on the resultant spectrum, and the results printed out. SETA is the vector where the background error is stored. ZETA is the storage vector for the intensities of the components to be subtracted from the spectrum, and TETA is the storage vector containing the error of each of the intensities. The control cards used in Flow 1 (Figure A–6) are as follows.

1. *Intensity Card—(1000 FORMAT)* (A6, 4X, A6, I4, 4I5, 3F10.0)
   a. Field 1 must contain the characters INTENS, or an error statement will be written and an exit from the program executed.
   b. Field 2 is ignored.
   c. Field 3 contains a 6-character identification code (ID). If the ID equals SAME (left adjusted), the computer will use the amplitudes and intensity errors as previously stored in Flow 1 by the last computation. This only works if Flow 1 was the last flow used.
   d. Field 4 contains the number of data points of the spectrum being analyzed (MRE).
   e. Field 5 contains the number of components to be subtracted from the spectrum (NNN).
   f. Field 6 contains the channel number of the first data point (MFE).
2. *Amplitude and Error Control Card—(1003 FORMAT)* (A6, 4X, 2F10.0)
   a. Field 1 must contain a name of up to six characters which corresponds to that of the component to be subtracted from the spectrum.
   b. Field 2 is ignored.
   c. Field 3 contains the intensity of the component to be subtracted from the spectrum (AMPLI).
   d. Field 4 contains the error associated with the intensity given in field 3 (ERROR).
3. *Background Error Control Card—(1000 FORMAT)* (A6, 4X, A6, I4, 4I5, 3F10.0)
   a. Field 1 must contain the six characters BACK E, or an error message will be written and an exit from the program then executed.
   b. Field 2 is ignored.
   c. Field 3 contains a 6-character identification (ID) code. If ID equals SAME (left adjusted), the same error as computed in the last Flow 1 will be used. If ID equals 1/OMEGA (left adjusted), the OMEGA value stored in S(I+2) by Flow 2 is used as the error. If the ID is neither of the two, the program expects OMEGA to be inputed from magnetic tape.
   d. Fields 4 and 6 correspond to the same fields on the intensity control card.
   e. Field 5 is ignored for Flow 1.

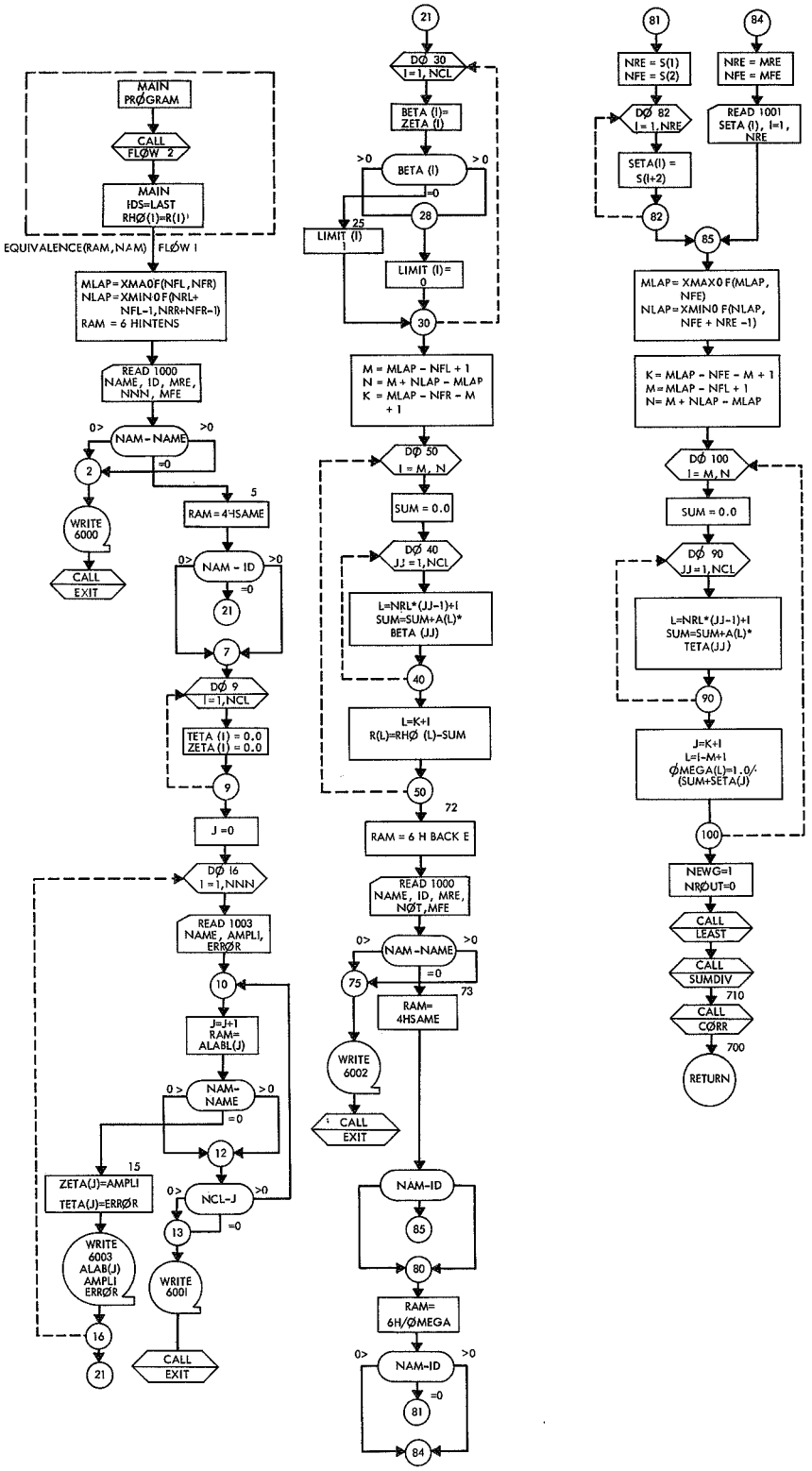
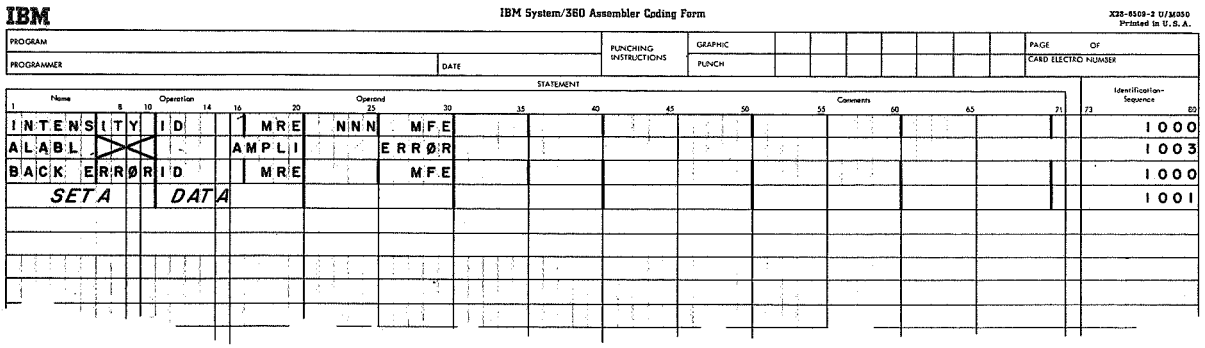


FIGURE A–5.—Flow 1 diagram.


IBM System/360 Assembler Coding Form

Name	Operation	Operand	Comments	Identification-Sequence
INTENSITY	ID	1 MRE NNN MFE		1000
ALABL		AMPLI ERRØR		1003
BACK ERRØR	ID	MRE MFE		1000
SETA	DATA			1001

FIGURE A–6.—Flow 1 control card format.

The intensity of each element and the associated error is read into the computer, and the associated library component is then multiplied by the intensity. The sum of all the components times their intensities (only those being stripped out) is then subtracted from the spectrum, and their individual limits are set equal to zero. Since their limits are zero, they are disregarded during the least-square analysis which is performed on the remainder of the spectrum.

FLOW 3

Flow 3 (shown in Figure A–7) is the library preparation subroutine. The "A" matrix (library storage), is divided in half, and the first half of the library read into the last half, destroying any components stored there. Thus for library preparation, the user has only 8000 spaces of memory at his command. The first component of the library is removed from storage in the last half of the memory ("AA" matrix), gain-shifted, zero-drifted, and fitted to a spectrum (RHO) until a minimum chi square is found between the limits set by the user. The component is then placed in the first half of the memory ("A" matrix) and the next component treated similarly. There must be as many component cards as components being prepared, and no component may be skipped over in the library. Thus if the first eight components are to be prepared, eight cards are to be present in the order that the components are stored in the library. After all of the components chosen have been prepared, the new library is punched out on IBM data cards as stored in the "A" matrix or normalized to one. The control is then returned to the main program, and analyses can be performed using either the new or old library. The new library is punched out in the exact format needed for insertion into any future Least-Square Program. The deck contains the library control cards, the component cards, and the data cards, as described earlier. The input for Flow 3 cards (Figure A–8) in order of appearance are as follows.

1. *Background Control Card—(1000 FORMAT)* (A6, 4X, A6, I4, 4I5, 3F10.0)

The description of this card will be found under Flow 2.

2. *Background Data Cards—(1001 FORMAT)* (7F10.0)

These also are described under Flow 2. If IFB=0 or −1, these cards will not be present; nor will the background control card be present.

3. *Component Control Card—(1004 FORMAT)* (A6, 4X, I5, 2F5.0, I5, 2F5.0, 2I5)
   a. Field 1 contains a 6-character identification code which must match that of the component stored in the library as ALABL(I). Thus if the second component of the library is being prepared, the second component control card must have the same identification (i.e., MN54=MN54). If they do not match exactly, an error statement will be written and an exit from the program executed.
   b. Field 2 is ignored.

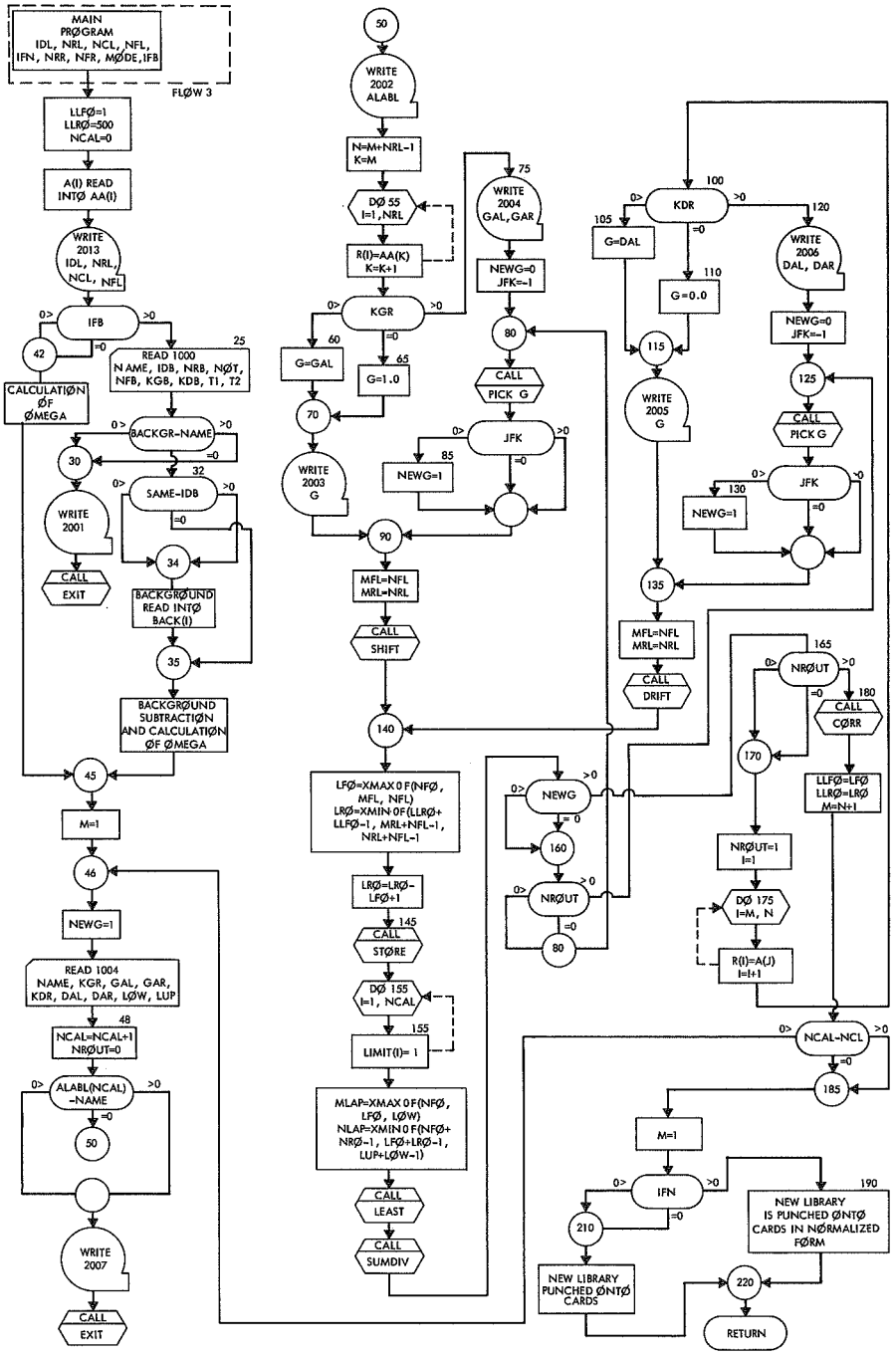


FIGURE A–8.—Flow 3 control card format.

c. Fields 3, 4, and 5 contain the gain shift key (KGR) for the component, the left limit of the shift (GAL), and the right limit of the shift (GAR), respectively. If KGR equals −1, GAL will be used for a constant gain shift. If KGR equals 0, the gain will be set equal to 1.0 (i.e., no change), and fields 4 and 5 ignored. If KGR equals 1, the gain-shift search will be made between GAL and GAR.

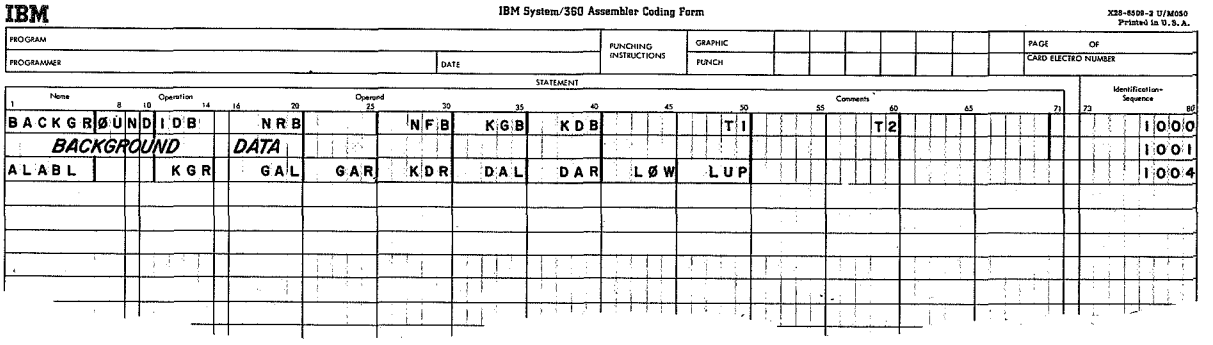


FIGURE A–7.—Flow 3, library preparation subroutine flow diagram.

d. Fields 6, 7, and 8 contain the zero drift key (KDR) associated with the component, the left limit of the drift search (DAL), and the right limit of the drift search (DAR), respectively. If KDR=0, there will be no drifting of the spectrum. If KDR=−1, the left-hand limit will be used as a constant drift multiplier.
e. Fields 9 and 10 contain the lower (LOW) and upper (LUP) limit of the spectrum, respectively, between which the component will be fitted.

PICKG

This subroutine is used to pick the gain factor by which the spectrum is multiplied in the gain-shift subroutine when the program is in the shift mode. It also picks the increment by which the spectrum is shifted while in the zero-drift mode. The subroutine is used only when in the search mode and must have two limits for searching, a right limit and a left limit. The program first uses the left limit and then uses the right limit for the next try. On the third try, a value one-half of the sum of the two limits is used. The program then begins to look for a minimum chi square value and picks a value halfway between the two points. The process is continued until the absolute value of two consecutively picked values is less than 0.01.

SHIFT

The shift subroutine is used to compensate for a shift in gain which may have occurred between the time that the library functions were recorded and the time that the spectrum was recorded. The pulse height is divided by, and the channel number multiplied by, the value of G from the PICKG subroutine or from the input shift card as in the case of a constant gain shift. In addition to shifting the spectrum, the shifted spectrum is stored in the DRR vector for use later in the DRIFT subroutine. The output from the subroutine contains the shifted spectrum corrected to whole channel numbers and the associated lower channel number after the shift and the number of data points.

DRIFT

The DRIFT subroutine compensates for any drift of the zero energy point with time. The DRR spectrum which was stored by the SHIFT subroutine is translated along the energy axis by the value of EPS calculated by the PICKG subroutine. The data output is again compensated so that only whole channel number values are kept. The limits of the new spectrum are also returned to the main program.

STORE

The STORE subroutine is used with Flow 2 to store the background component as the last component of the library. In Flow 3, it is used to store the shifted and drifted library components

back in the library. The position of the component being stored is set by the flow subroutines prior to entry into STORE.

LEAST

The subroutine LEAST performs the calculation of the linear least-square analysis. It is the entry point to the INVERT and MULT subroutines. The iteration which suppresses negative values occurs in this subroutine along with a printout of the relative intensities of the components being used.

SUMDIV

The SUMDIV subroutine prints out the actual versus the calculated spectrum and the percentage of difference. The value of chi square (Reference 6) is also calculated in the subroutine.

INVERT

The INVERT subroutine is used for the matrix inversion of the library function.

MULT

The MULT subroutine is used for matrix multiplication.

CORR

The CORR subroutine computes the statistical error associated with each component and the correlation matrix for the components used for the analysis of the spectrum. These values are printed out at the end of each analysis of a spectrum.

ILLUSTRATIVE PROBLEMS

In order to illustrate the uses of the Linear Least-Squares Program, two separate problems were run on the 7094 computer. A listing of the program (Exhibit A) and the data cards for use with the program (Exhibits B and C) follow the discussion of the illustrative problems so that the reader of this paper will be able to run the same problems on his own computer and compare his results with those given herein.

Problem 1 (Exhibit B) illustrates the use of Flows 1 and 2. The spectrum, background, and library components were counted using a NaI(Tl) crystal and a photomultiplier tube to feed the gamma-ray pulses into a multichannel analyzer. The sample consists of a mixture of the elements stored as library components. The sample was irradiated by a neutron flux from a nuclear reactor. The spectrum was counted for a period of 1 minute, 2 hours and 4 minutes after irradiation by the flux. The multichannel analyzer was used to record 200 channels of data of which the first nine channels were discarded because of noise and other nonuseful information.

The library GAMAGA consists of 191 data points and eleven elements, with the first data point being channel 10. The eleven elements, Na, Cl, K, Mn, Sc, A, As, Cu, Cr, I, and La, are then read into memory with each element preceded by a name card. Next, the spectrum 41259 of 191 data points beginning in channel 10 with a gain shift search and zero drift search requested is read into the RHO matrix. Flow 2 is requested with a background spectrum to be read into memory and all negative intensities are to be suppressed to zero.

The background of 191 data points starting with channel 10, no gain search, no zero search, and a counting time of 600 minutes is read into memory. The 1.0 on the background control card is the counting time of the spectrum 41259. The limits of the gain search are −4 percent to 10 percent of the actual spectrum. The expected zero drift limits are −2 to +2 channels. Both the gain limits and drift limits can be approximated by the experimenter as worst case values.

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Before continuing with the data cards, look at the results of the Flow 2 printout. Argon was rejected by the computer after both the gain shift and zero drift searches as not being present in the sample (i.e., not present in a detectable quantity). After the gain shift and zero drift, comparisons of the actual spectrum, the calculated spectrum, and their percent difference are printed out. The final gain shift value of 0.98187 giving a chi square value of 1.476 is printed after the comparison spectra. The final zero drift of −0.09766 channels giving a chi square value of 1.439 is found after the zero drift comparison spectra. At the end of the problem a correlation matrix is printed out. The diagonal elements of the matrix (i.e., A_{jj}, $j=1, 2, \ldots n$, where n is the number of components chosen) are the statistical error associated with each intensity given by the computer. If an element is eliminated by the computer, its row of the matrix will also be eliminated. The off-diagonal numbers (i.e., A_{ij}, where $i, j, =1, 2, 3, \ldots n$ and $i \neq j$) represent the correlation between components i and j. Thus Row 8 representing Cr has an error of ±0.424 and a correlation of: Na-Cr, 0.03 percent; Cl-Cr, 0.41 percent; K-Cr, 0.84 percent; Mn-Cr, 0.01 percent: Sc-Cr, 0.06 percent; As-Cr, 1.49 percent; and Cu-Cr, 0.08 percent.

Because of the high corre'ation between Na and Cl (i.e., 15.20 percent), Sc and Mn (38.61 percent), La and K (22.81 percent), Cu and La (12.98 percent), Cr and La (10.65 percent), and La and I (7.58 percent), the components with the longest half-lives were subtracted from the spectrum (i.e., Na, Sc. and La).

Because Flow 1 does not contain the background, shifting, or drifting options, the data are first processed by Flow 2. The spectrum called for LAST (left adjusted) to allow the background-subtracted, shifted, and drifted spectrum to be entered into Flow 1. Flow 1 is called for by the flow control card with no background expected, negative intensities suppressed, and NFTT and NRTT ignored. The intensity control card explains that three components are to be subtracted. The component cards then give the intensity and the associated error as calculated by the experimenter. The background error card causes the OMEGA calculated in Flow 2 to be used.

The results from Flow 1 show a printout of the three components subtracted, their intensity, and their error. The elements present after the least-squares analysis are listed along with their new intensities. The actual spectrum which is printed out is the spectrum after the subtraction of the three components. The correlation matrix for the remaining components is then printed out.

Problem 2 (Exhibit C) illustrates the use of Flow 2 and Flow 3; a mixture of three components was used for the spectrum. All 255 channels of data were read into the memory for the background, library components, and mixture.

The data were first run through Flow 2 to determine the goodness of fit of the data to the library. The spectrum Gamma 9 of 255 channels beginning with channel 1 was to to be searched for a gain shift and a zero drift. Since the background was not subtracted when the spectrum was first counted, a background subtraction was requested in Flow 2, negative intensities were suppressed, and the analysis was performed only between channels 3 and 255 (i.e., NFTT and NRTT). The background was counted for 800 minutes versus the 2.0 minutes for the spectrum. The limits of the shift reach and drift search were −10 percent to +10 percent and −5 to +5 channels, respectively. The results give a final chi square value of 107. 8.

After plotting the individual library components it was found that a zero drift and gain shift had taken place between the counting of the individual components making up the library.

The problem was resubmitted to Flow 3 (i.e., the library preparation subroutine). The shift limits for the components were ±5 percent and the drift limits for the components were selected as ± 2 channels. The limit for the gain shift of Na^{22} was later opened up to −5 percent to +10 percent because of the chi square value. Each component was fitted to the curve only in the area containing the component's photopeaks. The results of this run are given.

The spectrum was then rerun using this new library and Flow 2 to give a final chi square value of 2.45 after a gain and zero search.

EXHIBIT A
FORTRAN PROGRAM LISTING

```
C      PROGRAMMED SEPTEMBER 1966 AT GSFC, GREENBELT, MD.
C      ANALYSIS BY J. TROMBKA GSFC, PROGRAM BY R. SCHMADEBECK MELPAR
C      PROGRAMMING ADVICE BY R. BAXTER GSFC
CMAIN
C    LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA
       DIMENSION A(16000),ALABL(40),RHO(500),R(500),OMEGA(500),LIMIT(100)
       DIMENSION BETA(100),T(800),S(840),DRR(500),ZACK(500),BACK(500)
       COMMON A,ALABL,RHO,R,OMEGA,LIMIT,BETA,T,S,DRR,ZACK,BACK
       EQUIVALENCE (RAM,NAM)
       READ INPUT TAPE 2,1000,NAME,IDL,NRL,NCL,NFL,IFN
     6 RAM=6HLIBRAR
       IF(NAM-NAME)10,12,10
    10 WRITE OUTPUT TAPE 3,7000
       CALL EXIT
    12 RAM=6HLAST
       IF(NAM-IDL)15,13,15
    13 N=NRL*NCL
       DO 14 I=1,N
       K=8000+I
    14 A(I)=A(K)
       GO TO 21
    15 M=1
C LIBRARY IS READ INTO MEMORY
       DO 20 I=1,NCL
       N=M+NRL-1
       READ INPUT TAPE 2,1002,ALABL(I)
       READ INPUT TAPE 2,1001,(A(J),J=M,N)
    20 M=N+1
    21 READ INPUT TAPE 2,1000,NAME,IDS,NRS,NOT,NFS,KGR,KDR
       RAM=6HSPECTR
       IF(NAM-NAME)25,26,25
    25 WRITE OUTPUT TAPE 3,7001
       CALL EXIT
    26 RAM=4HSAME
       IF(NAM-IDS)27,34,27
    27 NRR=NRS
       NFR=NFS
       IDR=IDS
    30 RAM=4HLAST
       IF(NAM-IDR)33,31,33
    31 NRR=S(1)
       NFR=S(2)
       DO 32 I=1,NRR
    32 RHO(I)=R(I)
       GO TO 34
C SPECTRUM IS READ INTO RHO
    33 READ INPUT TAPE 2,1001,(RHO(I),I=1,NRR)
    34 WRITE OUTPUT TAPE 3,5000
       WRITE OUTPUT TAPE 3,5001,IDL,NCL,NRL,NFL
       RAM=4HFLOW
C FLOW CONTROL CARD
       READ INPUT TAPE 2,1000,NAME,NOF,NFLOW,MODE,IFB,NFTT,NRTT
       IF(NAM-NAME)35,36,35
    35 WRITE OUTPUT TAPE 3,7002
       CALL EXIT
    36 IF(NRTT)37,37,42
    37 NRTT=NRR
       NFTT=NFR
    42 WRITE OUTPUT TAPE 3,5002,IDR,NRR,NFR
    43 IF(MODE)44,44,46
    44 WRITE OUTPUT TAPE 3,5005,NFLOW
```

```
      GO TO 48
   46 WRITE OUTPUT TAPE 3,5006,NFLOW
   48 GO TO (50,60,70),NFLOW
   50 CALL FLOW1(NRL,NCL,NFL,NRR,NFR,MODE)
      GO TO 90
   60 CALL FLOW2(NRL,NCL,NFL,NRR,NFR,MODE,KGR,KDR,IFB,NFTT,NRTT)
      GO TO 90
   70 CALL FLOW3(IDL,NRL,NCL,NFL,IFN,NRR,NFR,MODE,IFB)
   90 READ INPUT TAPE 2,1000,NAME,IDS,NRS,NOS,NFS,KGR,KDR
      RAM=6HSPECTR
      IF(NAM-NAME)100,26,100
  100 RAM=4HFLOW
      IF(NAM-NAME)120,110,120
  110 NFLOW=NRS
      MODE=NOS
      IFB=NFS
      NFTT=KGR
      NRTT=KDR
      GO TO 36
  120 IDL=IDS
      NRL=NRS
      NCL=NOS
      NFL=NFS
      IFN=KGR
      GO TO 6
 1000 FORMAT(A6,4X,A6,I4,4I5,3F10)
 1001 FORMAT(7F10)
 1002 FORMAT(A6)
 5000 FORMAT(51H1LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA)
 5001 FORMAT(17HOFUNCTION LIBRARY,2X,A6,3X,2HOF,I4,2X,12HELEMENTS AND,I5,
     X2X,31HCHANNELS,STARTING WITH CHANNEL,I4)
 5002 FORMAT(24HOSPECTRUM TO BE ANALYZED,2X,A6,2X,2HOF,I4,2X,31HCHANNELS
     X,STARTING WITH CHANNEL,I4)
 5005 FORMAT(12H1FLOW OPTION,I3,5X,12HNO ITERATION)
 5006 FORMAT(12H1FLOW OPTION,I3,5X,14HITERATIVE MODE)
 7000 FORMAT(30HOERROR IN LIBRARY CONTROL CARD,14HOR END OF DATA)
 7001 FORMAT(31HOERROR IN SPECTRUM CONTROL CARD)
 7002 FORMAT(27HOERROR IN FLOW CONTROL CARD)
      END
```

```
CFLOW1
      SUBROUTINE FLOW1(NRL,NCL,NFL,NRR,NFR,MODE)
C SPECTRUM STRIPPING SUBROUTINE
      DIMENSION A(16000),ALABL(40),RHO(500),R(500),OMEGA(500),LIMIT(100)
      DIMENSION BETA(100),T(800),S(840),SETA(500),ZETA(100),TETA(100)
      COMMON A,ALABL,RHO,R,OMEGA,LIMIT,BETA,T,S,SETA,ZETA,TETA
      EQUIVALENCE (RAM,NAM)
      MLAP=XMAXOF(NFL,NFR)
      NLAP=XMINOF(NRL+NFL-1,NRR+NFR-1)
      RAM=6HINTENS
      READ INPUT TAPE 2,1000,NAME,ID,MRE,NNN,MFE
      IF(NAM-NAME)2,5,2
    2 WRITE OUTPUT TAPE 3,6000
      CALL EXIT
    5 RAM=4HSAME
      IF(NAM-ID)7,21,7
    7 DO 9 I=1,NCL
      TETA(I)=0.0
    9 ZETA(I)=0.0
      J=0
      DO 16 I=1,NNN
      READ INPUT TAPE 2,1003,NAME,AMPLI,ERROR
   10 J=J+1
      RAM=ALABL(J)
      IF(NAM-NAME)12,15,12
   12 IF(NCL-J)13,13,10
   13 WRITE OUTPUT TAPE 3,6001
      CALL EXIT
   15 ZETA(J)=AMPLI
      TETA(J)=ERROR
      WRITE OUTPUT TAPE 3,6003,ALABL(J),AMPLI,ERROR
   16 CONTINUE
   21 DO 30 I=1,NCL
      BETA(I)=ZETA(I)
      IF(BETA(I))28,25,28
   25 LIMIT(I)=1
      GO TO 30
   28 LIMIT(I)=0
   30 CONTINUE
      M=MLAP-NFL+1
      N=M+NLAP-MLAP
      K=MLAP-NFR-M+1
      DO 50 I=M,N
      SUM=0.0
      DO 40 JJ=1,NCL
      L=NRL*(JJ-1)+I
   40 SUM=SUM+A(L)*BETA(JJ)
      L=K+I
   50 R(L)=RHO(L)-SUM
   72 RAM=6HBACK E
      READ INPUT TAPE 2,1000,NAME,ID,MRE,NOT,MFE
      IF(NAM-NAME)75,73,75
   73 RAM=4HSAME
      IF(NAM-ID)80,85,80
   75 WRITE OUTPUT TAPE 3,6002
      CALL EXIT
   80 RAM=6H/OMEGA
      IF(NAM-ID)84,81,84
   81 NRE=S(1)
      NFE=S(2)
      DO 82 I=1,NRE
```

```
 82 SETA(I)=S(I+2)
    GO TO 85
 84 NRE=MRE
    NFE=MFE
    READ INPUT TAPE 2,1001,(SETA(I),I=1,NRE)
 85 MLAP=XMAXOF(MLAP,NFE)
    NLAP=XMINOF(NLAP,NFE+NRE-1)
    NFO=MLAP
    K=MLAP-NFE-M+1
    M=MLAP-NFL+1
    N=M+NLAP-MLAP
    DO 100 I=M,N
    SUM=0.0
    DO 90 JJ=1,NCL
    L=NRL*(JJ-1)+I
 90 SUM=SUM+A(L)*TETA(JJ)
    J=K+I
    L=I-M+1
    OMEGA(L)=1.0/(SUM+SETA(J))
100 CONTINUE
    NEWG=1
    NROUT=0
    CALL LEAST(NRL,NCL,NFL,NFR,NFO,MLAP,NLAP,NEWG,MODE,J,R)
    CALL SUMDIV(NRL,NCL,NFL,NFR,NFO,MLAP,NLAP,NEWG,TOTAL,G,NROUT,R)
710 CALL CORR(T,J,TOTAL)
700 RETURN
1000 FORMAT(A6,4X,A6,I4,4I5,3F10)
1001 FORMAT(7F10)
1003 FORMAT(A6,4X,2F10)
6000 FORMAT(13HOINPUT ERROR-,2X,85HFLOW 1 EXPECTS INTENSITY VECTOR FIRS
   XT, WHICH MUST BE COMPATIBLE WITH LIBRARY ELEMENTS)
6001 FORMAT(25HOERROR IN INTENSITY CARDS)
6002 FORMAT(13HOINPUT ERROR-,2X,71HFLOW 1 EXPECTS BACKGROUND ERROR VECT
   XOR AFTER THE INTENSITY ERROR VECTOR)
6003 FORMAT(27HOCOMPONENT TO BE SUBTRACTED,X,A6,X,7HBETA OF,X,F10.5,X,8
   XHERROR OF,X,F10.5)
    END
```

```
*      LIST
*      CARDS COLUMN
*      LABEL
CFLOW2
C GENERAL PURPOSE SUBROUTINE
      SUBROUTINE FLOW2(NRL,NCL,NFL,NRR,NFR,MODE,KGR,KDR,IFB,NFTT,NRTT)
      DIMENSION A(16000),ALABL(40),RHO(500),R(500),OMEGA(500),LIMIT(100)
      DIMENSION BETA(100),T(800),S(840),DRR(500),ZACK(500),BACK(500)
      DIMENSION DACK(500)
      COMMON A,ALABL,RHO,R,OMEGA,LIMIT,BETA,T,S,DRR,ZACK,BACK
      EQUIVALENCE (RAM,NAM)
      NTL=NCL
      NOMG=1
      MRR=NRR
      MFR=NFR
      NROUT=0
      IF(IFB)8,5,10
    5 WRITE OUTPUT TAPE 3,4000
      GO TO 65
    8 WRITE OUTPUT TAPE 3,4015
   10 RAM=6HBACKGR
      READ INPUT TAPE 2,1000,NAME,IDB,NRB,NOT,NFB,KGB,KDB,T1,T2
      IF(NAM-NAME)285,20,285
   20 RAM=4HSAME


      IF(NAM-IDB)25,30,25
   25 MRB=NRB
      MFB=NFB
C BACKGROUND IS READ INTO BACK
      READ INPUT TAPE 2,1001,(BACK(I),I=1,MRB)
   27 IF(NROUT)30,30,85
   30 RAM=6HBSHIFT
      IF(KGB)35,50,55
   35 READ INPUT TAPE 2,1003,NAME,GB
      IF(NAM-NAME)170,40,170
   40 WRITE OUTPUT TAPE 3,4002,GB
   45 CALL SHIFT(BACK,ZACK,MRB,MFB,GB,DACK,KDB)
      GO TO 65
   50 GB=1.0
      WRITE OUTPUT TAPE 3,4003
      GO TO 45
   55 READ INPUT TAPE 2,1003,NAME,GL,GR
      IF(NAM-NAME)170,60,170
   60 WRITE OUTPUT TAPE 3,4004,GL,GR
   65 RAM=6HRSHIFT
      IF(KGR)70,82,165
   70 READ INPUT TAPE 2,1003,NAME,GR
      IF(NAM-NAME)170,75,170
   75 WRITE OUTPUT TAPE 3,4005,GR
   80 NEWG=1
      CALL SHIFT(RHO,R,MRR,MFR,GR,DRR,KDR)
      GO TO 140
   82 GR=1.0
      WRITE OUTPUT TAPE 3,4006
      GO TO 80
   85 RAM=6HBDRIFT
      IF(KDB)90,102,105
   90 READ INPUT TAPE 2,1003,NAME,DB
      IF(NAM-NAME)170,95,170
   95 WRITE OUTPUT TAPE 3,4007,DB
```

```
100 MFB=LFB
    MRB=LRB
    CALL DRIFT(DACK,ZACK,MRB,MFB,DB)
    GO TO 115
102 DB=0.0
    WRITE OUTPUT TAPE 3,4008
    GO TO 100
105 READ INPUT TAPE 2,1003,NAME,GL,GR
    IF(NAM-NAME)170,110,170
110 WRITE OUTPUT TAPE 3,4009,GL,GR
115 RAM=6HRDRIFT
    IF(KDR)120,135,165
120 READ INPUT TAPE 2,1003,NAME,DR
    IF(NAM-NAME)170,125,170
125 WRITE OUTPUT TAPE 3,4010,DR
130 NEWG=1
    MFR=LFR
    MRR=LRR
    CALL DRIFT(DRR,R,MRR,MFR,DR)
    GO TO 140
135 DR=0.0
    WRITE OUTPUT TAPE 3,4011
    GO TO 130
140 IF(IFB)142,295,142
142 IF(NROUT)143,143,144
143 IF(KGB)230,230,177
144 IF(KDB)230,230,177
165 READ INPUT TAPE 2,1003,NAME,GL,GR
    RAM=6HRSHIFT
    IF(NAM-NAME)168,166,168
166 WRITE OUTPUT TAPE 3,4012,GL,GR
    GO TO 177
168 RAM=6HRDRIFT
    IF(NAM-NAME)170,175,170
170 WRITE OUTPUT TAPE 3,4013
    CALL EXIT
175 WRITE OUTPUT TAPE 3,4014,GL,GR
177 NEWG=0
    JFK=-1
178 CALL PICKG(GL,GR,G,TOTAL,JFK)
    IF(JFK)180,185,185
180 NEWG=1
185 IF(NROUT)190,190,210
190 IF(KGR)205,205,192
192 MRR=NRR
    MFR=NFR
    CALL SHIFT(RHO,R,MRR,MFR,G,DRR,KDR)
    IF(IFB)200,295,200
200 IF(KGB)230,230,205
205 MRB=NRB
    MFB=NFB
    CALL SHIFT(BACK,ZACK,MRB,MFB,G,DACK,KDB)
    GO TO 230
210 IF(KDR)220,220,212
212 MRR=LRR
    MFR=LFR
    CALL DRIFT(DRR,R,MRR,MFR,G)
    IF(IFB)215,295,215
215 IF(KDB)230,230,220
```

```
  220 MRB=LRB
      MFB=LFB
      CALL DRIFT(DACK,ZACK,MRB,MFB,G)
  230 IF(IFB)235,300,280
  235 I=NTL+1
C BACKGROUND IS STORED AS THE LAST COMPONENT OF THE LIBRARY
      ALABL(I)=6HBACKGR
      M=(NRL*NTL)+1
      N=NRL*I
      NCL=I
  240 CALL STORE(M,N,NRL,NFL,MRB,MFB,ZACK)
  275 GO TO 295
C BACKGROUND SUBTRACTION
  280 IF(T2)285,285,290
  285 WRITE OUTPUT TAPE 3,4001
      CALL EXIT
  290 TT=T1/T2
      NFO=XMAXOF(MFB,MFR)
      NRO=XMINOF(MFB+MRB-1,MFR+MRR-1)
      NRO=NRO-NFO+1
      KK=NFO-MFR
      LL=NFO-MFB
      DO 292 I=1,NRO
      K=KK+I
      L=LL+I
      OMEGA(I)=1.0/(R(K)+TT*ZACK(L))
  292 R(I)=R(K)-TT*ZACK(L)
      GO TO 350
  295 GO TO (300,330,350,340),NOMG
  300 RAM=5HOMEGA
      READ INPUT TAPE 2,1000,NAME,IDOM,NRO,NOT,NFO
      IF(NAM-NAME)302,305,302
  302 WRITE OUTPUT TAPE 3,4016
      CALL EXIT
  305 IF(NFO)320,320,310
  310 READ INPUT TAPE 2,1001,(OMEGA(I),I=1,NRO)
      GO TO 350
  320 RAM=5HUNITY
      IF(NAM-IDOM)325,330,325
  325 RAM=4HSAME
      IF(NAM-IDOM)340,327,340
  327 NOMG=3
      GO TO 350
  330 DO 335 I=1,NRL
  335 OMEGA(I)=1.0
      NOMG=2
      NFO=NFL
      NRO=NRL
      GO TO 350
  340 DO 345 I=1,MRR
  345 OMEGA(I)=1.0/R(I)
      NOMG=4
      NFO=MFR
      NRO=MRR
  350 DO 355 I=1,NCL
  355 LIMIT(I)=1
  360 MLAP=XMAXOF(NFL,MFR,NFO,NFTT)
      NLAP=XMINOF(NRL+NFL-1,MRR+MFR-1,NRO+NFO-1,NRTT)
  365 CALL LEAST(NRL,NCL,NFL,MFR,NFO,MLAP,NLAP,NEWG,MODE,J,R)
```

```
      CALL SUMDIV(NRL,NCL,NFL,MFR,NFO,MLAP,NLAP,NEWG,TOTAL,G,NROUT,R)
      IF(NEWG)178,178,380
  380 IF(NROUT)382,382,395
  382 NROUT=1
      LFB=MFB
      LRB=MRB
      LRR=MRR
      LFR=MFR
      IF(IFB)384,387,384
  384 IF(KDB)85,387,85
  387 IF(KDR)115,395,115
  395 CALL CORR(T,J,TOTAL)
      S(1)=NRO
      S(2)=NFO
      DO 400 I=1,NRO
  400 S(I+2)=1.0/OMEGA(I)
      G=1.0
      RETURN
 1000 FORMAT(A6,4X,A6,I4,4I5,3F10)
 1001 FORMAT(7F10)
 1003 FORMAT(A6,4X,2F10)
 4000 FORMAT(20HONO BACKGROUND GIVEN)
 4001 FORMAT(33HOERROR IN BACKGROUND CONTROL CARD)
 4002 FORMAT(23HOCONSTANT GAIN SHIFT OF,X,F10.4,13HON BACKGROUND)
 4003 FORMAT(28HONO GAIN SHIFT OF BACKGROUND)
 4004 FORMAT(28HOBACKGROUND GAIN SEARCH FROMX,F10.2,X,2HTO,X,F10.2)
 4005 FORMAT(35HOCONSTANT GAIN SHIFT OF SPECTRUM OFX,F10.4)
 4006 FORMAT(26HONO GAIN SHIFT OF SPECTRUM)
 4007 FORMAT(23HOCONSTANT ZERO DRIFT OF,X,F10.4,13HON BACKGROUND)
 4008 FORMAT(28HONO ZERO DRIFT OF BACKGROUND)
 4009 FORMAT(28HOBACKGROUND ZERO SEARCH FROMX,F10.2,X,2HTO,X,F10.2)
 4010 FORMAT(35HOCONSTANT ZERO DRIFT OF SPECTRUM OFX,F10.4)
 4011 FORMAT(26HONO ZERO DRIFT OF SPECTRUM)
 4012 FORMAT(26HOSPECTRUM GAIN SEARCH FROMX,F10.2,X,2HTOX,F10.2)
 4013 FORMAT(37HOERROR IN SHIFT OR DRIFT CONTROL CARD)
 4014 FORMAT(26HOSPECTRUM ZERO SEARCH FROMX,F10.2,X,2HTOX,F10.2)
 4015 FORMAT(47HOBACKGROUND STORED AS LAST COMPONENT OF LIBRARY)
 4016 FORMAT(47HOZERO BACKGROUND REQUIRES AN OMEGA CONTROL CARD)
      END
```

```
CFLOW3
C LIBRARY PREPARATION SUBROUTINE
      SUBROUTINE FLOW3(IDL,NRL,NCL,NFL,IFN,NRR,NFR,NODE,IFB)
      DIMENSION A(8000),AA(8000),ALABL(40),RHO(500),R(500),OMEGA(500)
      DIMENSION LIMIT(100),BETA(100),T(800),S(840),DRR(500),RE(500)
      DIMENSION BACK(500)
      COMMON A,AA,ALABL,RHO,R,OMEGA,LIMIT,BETA,T,S,DRR,RE,BACK
      EQUIVALENCE (RAM,NAM)
      LLFO=1
      LLRO=500
      NCAL=0
      N=NRL*NCL
      IF(N-8000)10,10,5
    5 N=8000
   10 DO 15 I=1,N
   15 AA(I)=A(I)
   20 M=1
      WRITE OUTPUT TAPE 3,2013,IDL,NRL,NCL,NFL
      IF(IFB)42,42,25
   25 READ INPUT TAPE 2,1000,NAME,IDB,NRB,NOT,NFB,KGB,KDB,T1,T2
      RAM=6HBACKGR
      IF(NAM-NAME)30,32,30
   30 WRITE OUTPUT TAPE 3,2001
      CALL EXIT
   32 RAM=4HSAME
      IF(NAM-IDB)34,35,34
C BACKGROUND IS READ INTO BACK
   34 READ INPUT TAPE 2,1001,(BACK(I),I=1,NRB)
   35 IF(T2)30,30,37
C BACKGROUND SUBTRACTION
   37 TT=T1/T2
      NFO=XMAXOF(NFB,NFR)
      NRO=XMINOF(NRB+NFB-1,NRR+NFR-1)
      NRO=NRO-NFO+1
      KK=NFO-NFR
      LL=NFO-NFB
      DO 40 I=1,NRO
      K=KK+I
      L=LL+I
      OMEGA(I)=1.0/(RHO(K)+TT*BACK(L))
   40 RHO(I)=RHO(K)-TT*BACK(L)
      GO TO 45
   42 DO 44 I=1,NRR
   44 OMEGA(I)=1.0/RHO(I)
      NRO=NRR
      NFO=NFR
   45 M=1
   46 NEWG=1
      READ INPUT TAPE 2,1004,NAME,KGR,GAL,GAR,KDR,DAL,DAR,LOW,LUP
   48 NCAL=NCAL+1
      NROUT=0
      LUP=LUP-LOW+1
      RAM=ALABL(NCAL)
      IF(NAM-NAME)49,50,49
   49 WRITE OUTPUT TAPE 3,2007
      CALL EXIT
   50 WRITE OUTPUT TAPE 3,2002,ALABL(NCAL)
      N=M+NRL-1
      K=M
      DO 55 I=1,NRL
      R(I)=AA(K)
```

```
 55 K=K+1
    IF(KGR)60,65,75
 60 G=GAL
    GO TO 70
 65 G=1.0
 70 WRITE OUTPUT TAPE 3,2003,G
    GO TO 90
 75 WRITE OUTPUT TAPE 3,2004,GAL,GAR
    NEWG=0
    JFK=-1
 80 CALL PICKG(GAL,GAR,G,TOTAL,JFK)
    IF(JFK)85,90,90
 85 NEWG=1
 90 MFL=NFL
    MRL=NRL
    CALL SHIFT(R,RE,MRL,MFL,G,DRR,KDR)
    GO TO 140
100 IF(KDR)105,110,120
105 G=DAL
    GO TO 115
110 G=0.0
115 WRITE OUTPUT TAPE 3,2005,G
    GO TO 135
120 WRITE OUTPUT TAPE 3,2006,DAL,DAR
    NEWG=0
    JFK=-1
125 CALL PICKG(DAL,DAR,G,TOTAL,JFK)
    IF(JFK)130,135,135
130 NEWG=1
135 MFL=NFL
    MRL=NRL
    CALL DRIFT(DRR,RE,MRL,MFL,G)
140 LFO=XMAXOF(LLFO,MFL,NFL)
    LRO=XMINOF(LLRO+LLFO-1,MRL+MFL-1,NRL+NFL-1)
    LRO=LRO-LFO+1
145 CALL STORE(M,N,NRL,NFL,MRL,MFL,RE)
150 DO 155 I=1,NCAL
155 LIMIT(I)=1
    MLAP=XMAXOF(NFO,LFO,LOW)
    NLAP=XMINOF(NFO+NRO-1,LFO+LRO-1,LUP+LOW-1)
    CALL LEAST(NRL,NCAL,NFL,NFO,NFO,MLAP,NLAP,NEWG,NODE,J,RHO)
    CALL SUMDIV(NRL,NCAL,NFL,NFO,NFO,MLAP,NLAP,NEWG,TOTAL,G,NROUT,RHO)
    IF(NEWG)160,160,165
160 IF(NROUT)80,80,125
165 IF(NROUT)170,170,180
170 NROUT=1
    I=1
    DO 175 J=M,N
    DRR(I)=A(J)
175 I=I+1
    GO TO 100
180 CALL CORR(T,J,TOTAL)
    LLFO=LFO
    LLRO=LRO
    M=N+1
    IF(NCAL-NCL)46,185,185
185 M=1
    IF(IFN)210,210,190
190 PUNCH 2012,IDL,NRL,NCAL,NFL
    DO 205 I=1,NCAL
    N=M+NRL-1
```

```
      SUM=0.0
      DO 195 J=M,N
  195 SUM=SUM+A(J)
      J=M
      DO 200 K=1,NRL
      R(K)=A(J)/SUM
  200 J=J+1
      WRITE OUTPUT TAPE 3,2011,ALABL(I)
      WRITE OUTPUT TAPE 3,2008,(R(J),J=1,NRL)
      PUNCH 2010,ALABL(I)
      PUNCH 2008,(R(J),J=1,NRL)
  205 M=N+1
      GO TO 220
  210 PUNCH 2012,IDL,NRL,NCAL,NFL
      DO 215 I=1,NCAL
      N=M+NRL-1
      WRITE OUTPUT TAPE 3,2011,ALABL(I)
      WRITE OUTPUT TAPE 3,2009,(A(J),J=M,N)
      PUNCH 2010,ALABL(I)
      PUNCH 2009,(A(J),J=M,N)
  215 M=N+1
  220 RETURN
 1000 FORMAT(A6,4X,A6,I4,4I5,3F10)
 1001 FORMAT(7F10)
 1004 FORMAT(A6,4X,I5,2F5,I5,2F5,2I5)
 2001 FORMAT(31HOERROR IN SPECTRUM CONTROL CARD)
 2002 FORMAT(24HOCOMPONENT BEING STORED-,2X,A6)
 2003 FORMAT(23HOCONSTANT GAIN SHIFT OF,2X,F10.5)
 2004 FORMAT(17HOGAIN SEARCH FROM,X,F10.5,X,2HTO,X,F10.5)
 2005 FORMAT(23HOCONSTANT ZERO DRIFT OF,2X,F10.5)
 2006 FORMAT(17HOZERO SEARCH FROM,X,F10.5,X,2HTO,X,F10.5)
 2007 FORMAT(25HOERROR IN NUMBER OF CARDS)
 2008 FORMAT(7F10.5)
 2009 FORMAT(7F10.2)
 2010 FORMAT(A6)
 2011 FORMAT(1HO,4X,9HCOMPONENT,X,A6)
 2012 FORMAT(7HLIBRARY,3X,A6,I4,2I5)
 2013 FORMAT(8HOLIBRARY,3X,A6,I4,2I5)
      END
```

```
CPICKG
C GAIN PICKING SUBROUTINE
      SUBROUTINE PICKG(GRL,GRR,G,TOTAL,JFK)
      DIMENSION Z(2),W(2)
      IF(JFK)10,20,30
   10 G=GRL
      JFK=0
      L=-1
      GO TO 100
   20 Z(2)=G
      W(2)=TOTAL
      G=GRR
      JFK=1
      GO TO 100
   30 IF(L)35,40,45
   35 Z(1)=G
      W(1)=TOTAL
      L=0
      KOUNT=0
   37 G=(Z(1)+Z(2))*0.5
      GO TO 100
   40 X=G
      Y=TOTAL
      L=1
      J=2
      GO TO 95
   45 IF(TOTAL-Y)70,70,60
   60 L=L
      Z(L)=G
      W(L)=TOTAL
      GO TO 80
   70 J=J
      Z(J)=X
      W(J)=Y
      X=G
      Y=TOTAL
   80 KOUNT=KOUNT+1
      IF(KOUNT-30)85,85,90
   85 IF(ABSF(Z(1)-Z(2))-.01)90,90,95
   90 JFK=-1
      GO TO 37
   95 L=XMODF(L,2)+1
      J=XMODF(J,2)+1
      G=(X+Z(L))*0.5
  100 RETURN
      END
```

```
CSHIFT
      SUBROUTINE SHIFT(RHO,R,MR,MF,G,DRR,KD)
C GAIN SHIFT SUBROUTINE
      DIMENSION DUM(17740),T(800),S(840),RHO(500),R(500),DRR(500)
      COMMON DUM,T,S
      F=MF
      AA=MF+MR-1
      DO 10 I=1,MR
      T(I)=G*FLOATF(MF-1+I)
   10 S(I)=RHO(I)/G
      MF=XMAX1F(G*F,F)
      MR=XMIN1F(G*AA,AA)
      IF(G-1.0)20,20,15
   15 AA=MF
      IF(AA-G*F)17,20,20
   17 MF=MF+1
   20 MR=MR-MF+1
      L=1
      DO 70 I=1,MR
      AA=MF-1+I
   25 IF(AA-T(L))40,60,30
   30 L=L+1
      GO TO 25
   40 R(I)=S(L-1)+(AA-T(L-1))*(S(L)-S(L-1))/G
      GO TO 62
   60 R(I)=S(L)
   62 IF(KD)65,70,65
   65 DRR(I)=R(I)
   70 CONTINUE
      RETURN
      END
```

```
CDRIFT
C ZERO DRIFT SUBROUTINE
      SUBROUTINE DRIFT(RHO,R,MR,MF,EPS)
      DIMENSION DUM(17740),T(800),S(840),RHO(500),R(500)
      COMMON DUM,T,S
      AA=MF+MR-1
      DO 10 I=1,MR
      T(I)=FLOATF(MF-1+I)+EPS
   10 S(I)=RHO(I)
      I=1
   15 IF(T(I))20,20,25
   20 I=I+1
      GO TO 15
   25 LEPS=EPS
      FEPS=LEPS
      IF(FEPS-EPS)50,30,50
   30 MF=T(I)
      MR=AA+EPS
      MR=MR-MF+1
      DO 45 J=1,MR
      R(J)=S(I)
   45 I=I+1
      GO TO 65
   50 MF=T(I)
      MF=MF+1
      F=MF
      MR=AA+EPS
      MR=MR-MF+1
      DO 60 J=1,MR
      R(J)=S(I)+(F-T(I))*(S(I+1)-S(I))
      I=I+1
      F=F+1.0
   60 CONTINUE
   65 RETURN
      END
```

```
CSTORE
C COMPONENT STORAGE SUBROUTINE
      SUBROUTINE STORE(M,N,NRL,NFL,MRL,MFL,RE)
      DIMENSION A(8000),AA(8000),RE(500)
      COMMON A,AA
      K=NFL
      II=MFL
      I=1
      J=M
    2 IF(K-II)5,15,10
    5 A(J)=0.0
      K=K+1
      J=J+1
      GO TO 2
   10 I=I+1
      II=II+1
      GO TO 2
   15 A(J)=RE(I)
   20 I=I+1
      II=II+1
      J=J+1
      IF(N-J)40,30,30
   30 IF(MRL-II)35,15,15
   35 A(J)=0.0
      GO TO 20
   40 RETURN
      END
```

```
CLEAST
      SUBROUTINE LEAST(NRL,NCL,NFL,NFR,NFO,MLAP,NLAP,NEWG,NODE,J,R)
      DIMENSION A(16000),ALABL(40),DUM(1000),OMEGA(500),LIMIT(100)
      DIMENSION BETA(100),T(1600),THETA(40),LIST(40),R(500)
      COMMON A,ALABL,DUM,OMEGA,LIMIT,BETA,T,THETA
      IF(NEWG)2,2,1
    1 WRITE OUTPUT TAPE 3,5000,MLAP,NLAP
    2 MODE=NODE
      M=MLAP-NFL+1
      N=NLAP-MLAP+1
      MRHO=MLAP-NFR+1
      MOMG=MLAP-NFO+1
      MAXCOL=0
      DO 5 I=1,NCL
      IF(LIMIT(I))5,5,3
    3 LIST(MAXCOL+1)=I
    5 MAXCOL=MAXCOL+LIMIT(I)
    7 ITER=MAXCOL
      IF(MODE)25,20,10
   10 ITER=2
   20 IF(NEWG)25,25,23
   23 WRITE OUTPUT TAPE 3,5001,(ALABL(I),I=1,NCL)
   25 DO 30 I=1,1640
   30 T(I)=0.0
      J=0
      DO 60 JJ=1,NCL
      IF(LIMIT(JJ))60,60,40
   40 J=J+1
      DO 50 I=1,N
      L=NRL*(JJ-1)+I+M-1
      K=MRHO+I-1
      LL=MOMG+I-1
      TT=A(L)*OMEGA(LL)
      THETA(J)=THETA(J)+TT*R(K)
      LL=0
      DO 50 KK=1,ITER
      K=ITER*(KK-1)+J
   45 LL=LL+1
      IF(LIMIT(LL))45,45,48
   48 L=NRL*(LL-1)+I+M-1
      T(K)=T(K)+TT*A(L)
   50 CONTINUE
      IF(J-ITER)60,80,80
   60 CONTINUE
   80 CALL INVERT(T,J)
      CALL MULT(T,THETA,BETA,J,J,1)
      IF(MODE)150,150,100
  100 LL=0
      KK=0
      DO 120 I=1,NCL
      IF(LIMIT(I))120,120,105
  105 KK=KK+1
      IF(BETA(KK))110,110,115
  110 LL=LL+1
      LIMIT(I)=-1
  115 IF(KK-J)120,130,130
  120 CONTINUE
  130 ITER=ITER-LL+1
      MAXCOL=MAXCOL-LL
      IF(ITER-MAXCOL)25,25,140
  140 IF(LL)150,150,145
```

```
  145 MODE=-1
      IF(ITER-1)150,150,7
  150 IF(NEWG)170,170,152
  152 WRITE OUTPUT TAPE 3,5002
      WRITE OUTPUT TAPE 3,5004
      LL=0
      J=0
      DO 160 I=1,NCL
      IF(LIMIT(I))155,155,156
  155 LL=LL+1
      LIST(LL)=I
      GO TO 160
  156 J=J+1
      WRITE OUTPUT TAPE 3,5005,ALABL(I),BETA(J)
  160 CONTINUE
      IF(LL)170,170,165
  165 WRITE OUTPUT TAPE 3,5003
      DO 167 K=1,LL
      I=LIST(K)
      WRITE OUTPUT TAPE 3,5006,ALABL(I)
  167 CONTINUE
  170 RETURN
 5000 FORMAT(38HOUSING FUNCTIONAL LIBRARY FROM CHANNEL,I4,3X,7HTHROUGH,
     X15)
 5001 FORMAT(19HOAND USING ELEMENTS,4X,16A6/(1H019A6))
 5002 FORMAT(1H0//47X,25HRELATIVE INTENSITY VECTOR)
 5003 FORMAT(21HOELIMINATING ELEMENTS)
 5004 FORMAT(1H0,34X,7HELEMENT,34X,9HINTENSITY/1H )
 5005 FORMAT(34X,A6,E47.6)
 5006 FORMAT(1H019A6/(1H019A6))
      END
```

```
CSUMDIV
      SUBROUTINE SUMDIV(NRL,NCL,NFL,NFR,NFO,MLAP,NLAP,NEWG,TOTAL,G,NROUT
     X,R)
      DIMENSION A(16000),ALABL(40),DUM(1000),OMEGA(500),LIMIT(100)
      DIMENSION BETA(100),R(500)
      COMMON A,ALABL,DUM,OMEGA,LIMIT,BETA
      M=MLAP-NFL+1
      N=M+NLAP-MLAP
      MRHO=MLAP-NFR-M+1
      MOMG=MLAP-NFO-M+1
      IF(NEWG)5,5,3
    3 WRITE OUTPUT TAPE 3,5000
      WRITE OUTPUT TAPE 3,5001
    5 TOTAL=0.0
      DO 50 I=M,N
      SUM=0.0
      KK=0
      DO 30 JJ=1,NCL
      IF(LIMIT(JJ))30,30,10
   10 KK=KK+1
      K=NRL*(JJ-1)+I
      SUM=SUM+BETA(KK)*A(K)
   30 CONTINUE
      J=MLAP+I-M
      K=MRHO+I
      L=MOMG+I
      DIF=R(K)-SUM
      TOTAL=TOTAL+OMEGA(L)*DIF**2
      DIF=DIF/R(K)
      IF(NEWG)50,50,40
   40 WRITE OUTPUT TAPE 3,5002,J,R(K),SUM,DIF
   50 CONTINUE
      DIF=N-M+1-KK
      TOTAL=TOTAL/ABSF(DIF)
      IF(NROUT)55,55,57
   55 IF(G)60,60,56
   56 WRITE OUTPUT TAPE 3,5003,G,TOTAL
      GO TO 70
   57 WRITE OUTPUT TAPE 3,5013,G,TOTAL
      GO TO 70
   60 WRITE OUTPUT TAPE 3,5004,TOTAL
   70 RETURN
 5000 FORMAT(84H1FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL S
     XPECTRA AND THEIR DIFFERENCES)
 5001 FORMAT(1H0,45X,6HACTUAL,17X,10HCALCULATED,9X,16HDIFFERENCE(P.C.)/8
     XH CHANNEL,37X,8HSPECTRUM,17X,8HSPECTRUM,10X,17HACTUAL-CALCULATED/1
     XH )
 5002 FORMAT(I6,21X,E28.6,E25.6,E23.6)
 5003 FORMAT(14H0GAIN SHIFT OF,F10.5,3X,22HGIVES CHI SQUARE VALUE,E15.6)
 5004 FORMAT(17H0CHI SQUARE VALUE,E15.6)
 5013 FORMAT(14H0ZERO DRIFT OF,F10.5,3X,22HGIVES CHI SQUARE VALUE,E15.6)
      END
```

```
CINVERT
      SUBROUTINE INVERT(A,N)
      DIMENSION A(16900),B(130),C(130),LA(130),LB(130)
    1 DO 220 K=1,N
C     DETERMINATION OF THE PIVOT ELEMENT
    2 PIVOT=0.0
    3 DO 70 I=K,N
    4 DO 70 J=K,N
      JAX=N*(J-1)+I
    5 IF(ABSF(A(JAX))-ABSF(PIVOT))70,70,6
    6 PIVOT=A(JAX)
      LA(K)=I
      LB(K)=J
   70 CONTINUE
C     EXCHANGE OF THE PIVOTAL ROW WITH THE KTH ROW
    8 IF(LA(K)-K)9,11,9
    9 LC=LA(K)
      DO 100 J=1,N
      JAX=N*(J-1)+LC
      JAY=N*(J-1)+K
   10 Z=A(JAX)
      A(JAX)=A(JAY)
  100 A(JAY)=Z
C     EXCHANGE OF THE PIVOTAL COLUMN WITH THE KTH COLUMN
   11 IF(LB(K)-K)12,14,12
   12 LC=LB(K)
      DO 130 I=1,N
      JAX=N*(LC-1)+I
      JAY=N*(K-1)+I
   13 Z=A(JAX)
      A(JAX)=A(JAY)
  130 A(JAY)=Z
C     JORDAN STEP
   14 DO 190 J=1,N
      JAX=N*(K-1)+J
      JAY=N*(J-1)+K
   15 CONTINUE
   16 IF(J-K)18,17,18
   17 B(J)=1.0/PIVOT
      C(J)=1.0
      GO TO 19
   18 B(J)=-A(JAY)/PIVOT
      C(J)=A(JAX)
   19 A(JAY)=0.0
  190 A(JAX)=0.0
   20 DO 220 I=1,N
   21 DO 220 J=1,N
      JAX=N*(J-1)+I
   22 A(JAX)=A(JAX)+C(I)*B(J)
  220 CONTINUE
C     REORDERING OF THE MATRIX
   23 K=N
   24 IF(LA(K)-K)25,27,25
   25 LC=LA(K)
      DO 250 I=1,N
      JAX=N*(LC-1)+I
      JAY=N*(K-1)+I
   26 Z=A(JAX)
      A(JAX)=A(JAY)
  250 A(JAY)=Z
   27 IF(LB(K)-K)28,295,28
```

```
 28 LC=LB(K)
    DO 290 J=1,N
    JAX=N*(J-1)+LC
    JAY=N*(J-1)+K
 29 Z=A(JAX)
    A(JAX)=A(JAY)
290 A(JAY)=Z
295 IF(K-1)310,310,300
300 K=K-1
    GO TO 24
310 RETURN
    END
```

```
CMULT
      SUBROUTINE MULT(A,B,C,I,J,K)
      DIMENSION A(2),B(2),C(2)
      MM=1
      NN=1
      NJ=J
      DO 30 NA=1,K
      DO 20 LL=1,I
      N=LL
      C(MM)=0.0
      DO 10 L=NN,NJ
      C(MM)=C(MM)+A(N)*B(L)
   10 N=N+I
      MM=MM+1
   20 CONTINUE
      NN=NJ+1
      NJ=NJ+J
   30 CONTINUE
      RETURN
      END
```

```
CCORR
      SUBROUTINE CORR(T,NCOL,TOTAL)
      DIMENSION T(40),V(40)
      SSS=SQRTF(TOTAL)
      WRITE OUTPUT TAPE 3,5000
      DO 50 I=1,NCOL
      M=NCOL*(I-1)
      K=M+I
      KK=I-1
      IF(KK)20,45,20
   20 DO 40 J=1,KK
      L=M+J
      N=NCOL*(J-1)+J
   40 V(J)=T(L)**2/(T(K)*T(N))
   45 V(I)=SQRTF(2.0*T(K))
      WRITE OUTPUT TAPE 3,5001,I
      V(I)=V(I)*SSS
      WRITE OUTPUT TAPE 3,5002,(V(J),J=1,I)
   50 CONTINUE
      RETURN
 5000 FORMAT(19HOCORRELATION MATRIX,10X,71HSTANDARD DEVIATION = DIAGONAL
     X ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE/29X,40HOFF DIAGONAL ELE
     XMENT = CROSS CORRELATION)
 5001 FORMAT(4HOROWI4/1H )
 5002 FORMAT(7E16.5)
      END
```

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EXHIBIT B

DATA CARD LISTING AND COMPUTER PRINTOUT FOR PROBLEM 1

INPUT DATA CARDS FOR FLOW 2 AND FLOW 1

```
LIBRARY   GAMAGA 191   11   10
NA
8.39      8.04      8.36      8.48      9.43      10.44     10.22
9.49      8.61      8.48      7.89      7.19      6.64      6.31
6.07      5.74      5.80      5.37      5.00      5.71      5.19
5.07      6.52      8.27      9.01      7.44      4.92      4.54
4.52      3.85      4.10      3.85      3.88      4.06      4.04
3.68      3.75      4.07      3.76      3.66      3.65      3.78
3.69      3.77      3.71      3.49      3.75      3.93      3.78
3.76      3.75      3.94      3.80      3.88      3.91      4.00
4.04      4.22      3.99      3.94      4.66      4.32      4.10
3.79      3.59      3.61      3.32      2.45      2.42      1.94
1.87      1.94      1.70      1.75      1.26      2.31      3.13
4.25      6.18      9.86      13.57     15.61     15.00     11.56
7.30      3.56      2.21      1.20      1.11      1.01      1.04
1.02      0.89      0.86      1.04      1.02      1.09      1.08
0.96      0.96      1.16      1.41      1.83      1.89      1.66
1.69      1.62      1.64      1.57      1.26      1.20      1.25
1.26      1.40      1.33      1.40      1.40      1.31      1.38
1.44      1.45      1.09      1.62      1.49      1.36      1.33
1.29      1.34      1.11      1.21      1.08      1.38      1.44
1.28      1.49      1.59      1.56      1.56      2.46      3.10
3.03      2.85      2.94      2.47      1.97      2.13      2.02
2.19      2.09      2.00      1.64      2.07      1.86      1.95
1.50      1.54      1.59      1.33      1.09      0.84      0.77
0.59      0.65      0.51      0.48      0.54      0.45      1.07
1.47      2.36      3.10      4.44      5.30      6.04      5.66
4.85      3.71      3.25      2.24      1.24      0.82      0.38
0.23      0.11      0.09      .05       .02       0.0       0.0
0.0       0.0
CL
   10.0400    9.2500    8.6600    7.6700    8.5500    9.2000    9.0900    087
    8.3300    7.8600    7.7700    6.3900    5.9600    6.1800    5.6900    088
    5.1500    4.9100    4.6700    4.3400    4.3400    4.4300    4.5200    089
    4.5300    4.6900    6.1600    6.6600    5.5200    4.2100    3.1800    090
    2.8300    3.3200    3.2000    2.9800    3.4000    3.3400    3.0800    091
    3.1000    2.7100    2.8300    3.2500    2.5900    2.5900    2.4000    092
    2.7300    2.7400    2.5200    2.8300    2.6000    2.9000    2.7900    093
    2.7600    2.8300    2.6800    2.7400    2.8600    3.0000    3.0900    094
    2.3100    2.7900    2.7600    2.4600    2.7800    2.7500    2.8100    095
    2.9800    3.1800    3.2900    3.5500    3.5200    3.3300    2.9000    096
    2.9800    2.6200    3.0800    3.1000    2.9400    3.6500    4.1200    097
    3.9500    4.0100    3.9300    3.4600    3.2500    3.1000    2.8100    098
    2.1600    2.2300    2.0300    1.9700    2.0100    1.7300    1.8900    099
    1.7500    1.5500    1.5500    1.7500    2.3000    3.5800    4.7800    100
    7.1400    8.8100    9.5100    9.0700    7.9100    5.4100    4.2000    101
    2.7600    2.1100    1.8700    1.8600    1.8800    1.9700    1.8000    102
    2.0300    2.1300    2.1600    1.9900    1.8300    1.7900    1.1800    103
    1.2700    1.1300     .8900     .6600     .7600     .6400     .4500    104
     .4500     .4200     .6100     .7800    1.4800    2.3500    3.8700    105
    5.3000    6.4800    7.0200    6.6100    5.8000    3.9300    2.7300    106
    1.5000     .7700     .5800     .1900     .1200     .0600     .0400    107
     .1200     .0200     .0900     .0500     .0800     .0800     .0100    108
     .0400     .0500     .0200     .0700     .0200     .0500     .0500    109
     .0300     .0600     .0500     .0200     .0400     .0100     .0200    110
     .0400     .0200     .0600     .0300     .0600     .0900     .0600    111
     .0600     .0800     .0300     .0200     .0200     .0300     .0100    112
     .0300     .0200     .0300     .0200     .0400     .0200     .0300    113
0.011     0.01
```

```
K
21.85     18.74     16.93     15.48     16.10     16.56     15.69
12.62     13.15     13.43     12.42     9.32      8.30      8.87
7.55      7.74      7.25      6.98      6.94      6.37      6.24
6.60      7.69      7.34      6.93      6.00      5.50      4.82
4.82      4.80      5.62      4.75      4.71      4.96      4.88
4.83      4.69      4.56      4.52      4.53      4.63      4.53
4.43      4.27      4.53      4.68      4.60      4.54      4.27
4.86      4.14      4.97      4.46      4.51      4.31      4.94
4.91      4.96      5.29      5.46      5.09      4.80      4.95
4.55      4.81      4.61      4.96      4.65      5.05      5.02
5.45      5.63      5.43      5.60      5.22      5.17      4.38
4.17      3.26      2.66      2.40      2.34      2.05      1.75
1.35      1.23      1.90      3.86      6.58      11.51     17.55
22.36     23.16     18.83     13.64     7.58      3.46      1.33
0.52      0.27      0.16      0.07      0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
MN
   15.1700   13.9000   15.1300   16.8000   17.4200   16.8800   15.8100    059
   14.8600   14.2300   13.0000   12.1400   11.8200   11.2500   11.1100    060
    9.9800   10.7800   10.0300    9.3300    9.6000    9.2200    9.2500    061
    9.8700    9.5300   10.0800   10.3200    9.9600    9.8600    8.9200    062
    9.0900    9.2600    9.4600    8.4000    7.4700    6.4200    5.6100    063
    4.8700    4.4000    4.1800    3.7600    4.1400    3.7600    4.0100    064
    4.2500    5.0300    9.3600   18.7500   32.8800   42.6700   39.9300    065
   26.5400   12.4100    4.7300    2.2200    1.5600    1.4600    1.2000    066
    1.3200    1.4700    1.6000    1.2600    1.4800    1.5500    1.6300    067
    1.6100    1.6000    1.3600    1.2000    1.2100    1.0600    1.2000    068
    1.5700    1.2300    1.2100    1.3700    1.6700    1.7200    1.7000    069
    1.7000    1.6800    1.6200    1.6000    1.6000    1.6000    1.6000    070
    1.6000    1.6000    1.5900    1.6000    1.6000    1.5500    1.5600    071
    1.4400    1.6200    1.3800    1.3500    1.2700    1.1700    1.1200    072
     .9600    1.0000    1.1600    1.2100     .8900     .8400     .8200    073
     .7100     .8000     .9300    1.4100    1.9000    2.6700    3.8700    074
    4.7400    4.4300    4.3900    3.6800    2.2500    1.6400    1.0400    075
     .6200     .3200     .4400     .4000     .2500     .3600     .1400    076
     .3200     .3600     .4700     .6500     .9200    1.3700    1.5800    077
    1.8800    1.9500    1.5800    1.5200    1.1500     .7800     .5800    078
     .3000     .3200     .2500     .2600     .1800     .2700     .1800    079
     .1300     .1300     .1700     .1400     .1600     .1200     .0800    080
     .1000     .1700     .1800     .1700     .1600     .1700     .2700    081
     .2200     .1700     .0900     .1500     .0700     .2000     .1200    082
     .1800     .0900     .1000     .1000     .1600     .2100     .1400    083
     .2700     .1900     .1400     .1500     .1500     .1600     .1700    084
     .0600     .0300     .0200     .0100     .0100     .0300     .0200    085
0.03      0.05
```

```
SC
   18.3800   18.3300   17.6000   20.1300   24.0500   22.5600   21.3500        031
   19.0000   18.1900   16.6300   15.9300   15.1200   14.1600   14.1000        032
   14.1600   13.5200   12.6500   12.3300   12.3700   11.7400   11.9800        033
   12.4700   12.2800   11.7800   10.9800   11.6500   11.7500   10.9200        034
   11.0200   11.7200   11.3700   11.7800   11.9000   11.1300   10.3300        035
    8.8500    8.4600    7.4300    7.8000    7.2600    7.6000    7.2600        036
    7.3700    7.4400    7.6500   11.0600   17.8800   28.7300   40.1100        037
   40.4000   28.8900   15.3100    6.2400    2.7900    1.7600    1.5300        038
    1.4300    1.4900    1.5200    2.3100    4.3500   10.0700   17.9400        039
   25.4100   28.3200   23.7400   14.3800    7.6200    2.6300     .7800        040
     .3200     .3000     .2100     .1800     .2900     .2200     .2600        041
     .2600     .2600     .2600     .2600     .2600     .2600     .2600        042
     .2700     .1300     .2500     .1900     .2400     .0600     .2000        043
     .2200     .1700     .2300     .0700     .1900     .1700     .0900        044
     .1200     .1300     .1300     .1800     .1200     .1600     .1700        045
     .0900     .1100     .1400     .1700     .1100     .1100     .1500        046
     .1400     .0300     .0600     .0600     .1100     .0400     .0600        047
     .0900     .0400     .0600     .1200     .1600     .2200     .2700        048
     .1800     .1900     .1700     .1400     .0700     .0400     .0300        049
     .0400     .0500     .0200     .0300     .0400     .0800     .0300        050
     .0800     .0600     .0800     .0500     .0300     .0200     .0500        051
     .0400     .0700     .0000     .0400     .0100     .0100     .0200        052
     .0000     .0700     .0200     .0100     .0200     .0100     .0200        053
     .0000     .0000     .0000     .0000     .0300     .0100     .0300        054
     .0600     .0600     .0900     .1000     .0800     .1100     .0500        055
     .0400     .0300     .0000     .0200     .0000     .0000     .0000        056
     .0000     .0000     .0100     .0000     .0300     .0100     .0000        057
0.01      0.0
A
    7.1800    6.6000    6.8100    6.7200    7.6800    8.8500    8.8700        003
    8.2400    7.2000    6.4200    6.4100    6.0000    5.8400    5.3700        004
    5.5400    5.2800    5.0500    4.7900    5.1700    4.4900    4.7800        005
    4.3400    4.5100    4.4700    4.8500    4.5700    4.3800    4.2000        006
    4.0500    4.0800    3.7700    4.0400    4.4300    4.3100    4.1700        007
    3.9400    4.3100    4.4300    4.4700    3.9500    4.1200    4.2900        008
    4.1500    4.4000    4.5800    4.3100    4.5400    4.1600    4.8000        009
    4.7800    4.7200    4.9800    4.9800    5.0200    5.0000    5.1900        010
    5.2400    5.5300    5.3700    4.7100    3.8000    3.4400    2.5700        011
    2.3900    1.7600    1.4000    1.4000    1.2000    1.0500     .9600        012
    1.0000    1.7000    3.9000    8.2700   15.0600   22.5300   26.8300        013
   25.8900   18.3400   10.6300    5.0800    1.8000     .5100     .1300        014
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        015
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        016
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        017
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        018
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        019
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        020
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        021
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        022
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        023
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        024
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        025
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        026
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        027
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        028
     .0000     .0000     .0000     .0000     .0000     .0000     .0000        029
0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

AS

15.42	15.31	18.53	17.82	15.60	15.16	13.75
13.33	12.19	11.75	11.81	11.31	10.71	11.25
10.01	8.01	7.32	6.65	6.27	6.21	5.98
5.66	5.73	6.00	8.72	17.73	35.76	49.43
39.42	17.74	5.04	2.87	3.78	5.86	5.94
4.28	2.42	1.23	1.04	0.96	1.02	1.00
1.13	1.02	1.08	0.96	1.02	1.03	0.94
0.94	0.94	0.83	0.96	0.88	1.03	0.82
0.73	0.73	0.63	0.58	0.52	0.59	0.41
0.31	0.43	0.52	0.46	0.61	1.03	1.69
2.15	2.40	2.30	1.97	1.63	1.46	1.32
1.03	0.84	0.83	0.65	0.59	0.60	0.39
0.37	0.24	0.26	0.28	0.26	0.17	0.08
0.09	0.10	0.06	0.12	0.09	0.09	0.13
0.13	0.14	0.07	0.07	0.10	0.15	0.13
0.17	0.12	0.17	0.11	0.15	0.09	0.11
0.10	0.17	0.12	0.09	0.07	0.07	0.02
0.06	0.12	0.06	0.04	0.03	0.06	0.06
0.05	0.19	0.14	0.19	0.22	0.18	0.17
0.22	0.13	0.10	0.08	0.03	0.08	0.06
0.05	0.10	0.11	0.06	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0					

CU

14.37	16.14	19.33	16.94	15.83	15.05	13.82
13.45	13.36	12.98	13.04	11.72	9.25	8.38
7.78	7.51	7.02	6.99	7.33	7.14	7.22
11.70	29.12	55.99	66.01	43.02	13.94	2.65
0.63	0.64	0.69	0.53	0.43	0.54	0.58
0.66	0.76	0.62	0.57	0.45	0.48	0.35
0.46	0.41	0.35	0.43	0.47	0.47	0.60
0.42	0.35	0.44	0.30	0.38	0.48	0.46
0.59	0.46	0.42	0.45	0.39	0.22	0.31
0.31	0.15	0.17	0.19	0.11	0.09	0.08
0.13	0.32	0.51	0.66	1.54	1.44	1.74
1.44	1.04	0.76	0.71	0.43	0.38	0.20
0.09	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0					

CR

23.41	21.82	17.39	14.70	14.54	14.08	15.27
15.99	17.10	27.12	79.09	112.62	55.27	7.19
0.18	0.0	0.0	0.0	0.0	0.0	0.0
0.0

```
LA
37.74     40.69     40.32     38.12     38.34     38.93     37.78
34.49     34.87     33.78     41.74     59.83     51.02     27.49
19.28     17.66     18.10     19.72     20.46     22.58     32.87
55.65     65.65     48.59     23.49     13.50     10.26     10.31
10.01     9.31      9.08      8.86      7.93      7.87      7.62
7.28      7.81      8.02      8.91      9.53      10.02     11.32
15.02     19.64     20.73     17.66     12.96     10.28     8.87
9.42      9.88      9.54      9.87      7.12      5.76      5.73
5.00      4.82      4.73      4.80      5.22      5.72      6.37
5.84      5.76      5.76      5.68      5.19      5.69      5.56
5.65      5.81      6.11      6.28      6.34      5.99      5.83
5.85      5.17      4.65      3.85      3.48      3.07      2.41
1.96      1.82      1.72      1.54      1.57      1.95      2.59
5.11      10.11     16.20     22.91     25.90     24.69     19.39
13.38     7.70      3.38      1.72      1.13      0.50      0.48
0.45      0.34      0.44      0.34      0.40      0.50      0.48
0.41      0.42      0.44      0.35      0.47      0.39      0.52
0.35      0.37      0.46      0.41      0.50      0.52      0.54
0.40      0.50      0.46      0.38      0.57      0.28      0.41
0.38      0.33      0.27      0.25      0.29      0.21      0.26
0.24      0.14      0.27      0.17      0.28      0.30      0.25
0.22      0.15      0.18      0.16      0.24      0.25      0.48
0.43      0.53      0.62      0.73      0.52      0.44      0.33
0.33      0.21      0.15      0.05      0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.        0.
SPECTRUM   41259 191          10    1    1
1203.0    1189.0    1105.0    1052.0    1092.0    1084.0    1059.0
1041.0    970.0     953.0     1080.0    1330.0    1291.0    853.0
632.0     588.0     500.0     518.0     534.0     546.0     581.0
592.0     649.0     819.0     866.0     870.0     769.0     816.0
809.0     657.0     438.0     311.0     319.0     344.0     324.0
333.0     301.0     275.0     234.0     259.0     248.0     285.0
225.0     262.0     279.0     337.0     450.0     507.0     517.0
462.0     456.0     429.0     306.0     291.0     236.0     189.0
208.0     182.0     219.0     188.0     202.0     211.0     233.0
247.0     264.0     324.0     319.0     303.0     237.0     219.0
189.0     179.0     178.0     166.0     179.0     172.0     176.0
162.0     197.0     231.0     285.0     338.0     389.0     383.0
365.0     256.0     163.0     144.0     106.0     122.0     126.0
190.0     237.0     270.0     288.0     273.0     234.0     202.0
204.0     186.0     174.0     177.0     160.0     150.0     126.0
112.0     88.0      74.0      73.0      66.0      70.0      74.0
75.0      70.0      75.0      66.0      66.0      59.0      55.0
64.0      41.0      35.0      44.0      39.0      27.0      37.0
42.0      39.0      41.0      58.0      47.0      41.0      53.0
75.0      83.0      100.0     114.0     107.0     116.0     117.0
102.0     95.0      83.0      85.0      71.0      67.0      64.0
55.0      42.0      35.0      34.0      48.0      31.0      50.0
40.0      23.0      43.0      44.0      36.0      36.0      27.0
27.0      20.0      26.0      11.0      16.0      13.0      11.0
15.0      12.0      21.0      30.0      51.0      49.0      89.0
104.0     108.0     110.0     102.0     97.0      57.0      40.0
32.0      16.0      13.0      8.0       5.0       2.0       2.0
1.0       1.0
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FLOW                    2     1     1
BACKGROUND            191          10     0     0        1.0      600.0
   7168.00     6776.00     6851.00     6827.00     6587.00     6437.00     6313.00
   5508.00     5076.00     4995.00     4566.00     4209.00     4121.00     3952.00
   3664.00     3205.00     3020.00     2821.00     2692.00     2502.00     2491.00
   2361.00     2620.00     2743.00     2707.00     2293.00     1892.00     1710.00
   1666.00     1744.00     1689.00     1607.00     1501.00     1362.00     1276.00
   1178.00     1137.00     1211.00     1128.00     1218.00     1211.00     1128.00
   1104.00     1017.00      977.00      954.00      893.00      886.00      910.00
    884.00      908.00      900.00      800.00      804.00      794.00      754.00
    775.00      739.00      725.00      727.00      733.00      706.00      714.00
    687.00      726.00      680.00      722.00      700.00      627.00      629.00
    572.00      559.00      537.00      500.00      495.00      502.00      469.00
    490.00      445.00      448.00      432.00      440.00      473.00      493.00
    554.00      661.00      745.00      757.00      733.00      550.00      448.00
    351.00      296.00      279.00      274.00      251.00      263.00      250.00
    256.00      248.00      219.00      228.00      221.00      237.00      222.00
    255.00      199.00      272.00      258.00      205.00      192.00      207.00
    187.00      169.00      179.00      162.00      165.00      166.00      162.00
    134.00      147.00      145.00      138.00      126.00      162.00      153.00
    153.00      148.00      145.00      161.00      140.00      187.00      160.00
    159.00      162.00      166.00      142.00      137.00      136.00      127.00
    140.00      143.00      126.00       95.00      111.00      112.00      114.00
    110.00      111.00      105.00      103.00      100.00       87.00      105.00
    103.00       79.00       94.00       98.00       93.00       97.00      109.00
    137.00      129.00      185.00      129.00      135.00      102.00       98.00
     87.00       81.00       84.00       78.00       69.00       82.00       73.00
     67.00       62.00       69.00       63.00       65.00       61.00       63.00
     53.00       67.00       61.00       60.00       58.00       51.00       64.00
     51.00       58.00
RSHIFT                .96        1.10
RDRIFT              -2.0         2.0
SPECTRUM  LAST      191          10     1     1
FLOW                  1     1     0     1
INTENSITY           191     3    10
NA                18.73         .134
SC                 4.831        .130
LA                 3.412        .159
BACK ERR  /OMEGA  191          10
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RESULTS FROM FLOW 2
PROBLEM 1

LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA

FUNCTION LIBRARY GAMAGA OF 11 ELEMENTS AND 191 CHANNELS,STARTING WITH CHANNEL, 10

SPECTRUM TO BE ANALYZED 41259 OF 191 CHANNELS,STARTING WITH CHANNEL, 10

FLOW OPTION 2 ITERATIVE MODE

NO GAIN SHIFT OF BACKGROUND

SPECTRUM GAIN SEARCH FROM 0.96 TO 1.10

GAIN SHIFT OF 0.96000 GIVES CHI SQUARE VALUE 0.127169E 02

GAIN SHIFT OF 1.10000 GIVES CHI SQUARE VALUE 0.397427E 02

GAIN SHIFT OF 1.03000 GIVES CHI SQUARE VALUE 0.339831E 02

GAIN SHIFT OF 0.99500 GIVES CHI SQUARE VALUE 0.553404E 01

GAIN SHIFT OF 1.01250 GIVES CHI SQUARE VALUE 0.199307E 02

GAIN SHIFT OF 0.97750 GIVES CHI SQUARE VALUE 0.220433E 01

GAIN SHIFT OF 0.98625 GIVES CHI SQUARE VALUE 0.174688E 01

GAIN SHIFT OF 0.98187 GIVES CHI SQUARE VALUE 0.147630E 01

USING FUNCTIONAL LIBRARY FROM CHANNEL 10 THROUGH 196

AND USING ELEMENTS NA CL K MN SC A AS CU CR I LA

RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
NA	0.196739E 02
CL	0.125360E 02
K	0.945598E 01
MN	0.439359E 01
SC	0.453146E 01
AS	0.110658E 02
CU	0.385386E 01
CR	0.490055E 01
I	0.856883E 00
LA	0.394472E 01

ELIMINATING ELEMENTS

A

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
10	0.121063E 04	0.115754E 04	0.438505E-01
11	0.118228E 04	0.111811E 04	0.542829E-01
12	0.110202E 04	0.112693E 04	-0.226027E-01
13	0.106982E 04	0.107978E 04	-0.931158E-02
14	0.109908E 04	0.110501E 04	-0.539222E-02
15	0.108623E 04	0.111911E 04	-0.302724E-01
16	0.106261E 04	0.107590E 04	-0.125020E-01
17	0.102834E 04	0.991347E 03	0.359780E-01
18	0.973693E 03	0.958489E 03	0.156142E-01
19	0.100763E 04	0.981418E 03	0.260160E-01
20	0.118633E 04	0.122220E 04	-0.302359E-01
21	0.133214E 04	0.139351E 04	-0.460717E-01
22	0.112680E 04	0.103583E 04	0.807382E-01
23	0.766597E 03	0.702651E 03	0.834160E-01
24	0.617707E 03	0.590312E 03	0.443487E-01
25	0.552152E 03	0.552726E 03	-0.104074E-02
26	0.512995E 03	0.531873E 03	-0.368000E-01
27	0.530982E 03	0.519036E 03	0.224978E-01
28	0.545688E 03	0.540242E 03	0.997903E-02
29	0.570991E 03	0.581217E 03	-0.179084E-01
30	0.593777E 03	0.599954E 03	-0.104015E-01
31	0.632213E 03	0.668950E 03	-0.581075E-01
32	0.758887E 03	0.797559E 03	-0.509580E-01
33	0.858706E 03	0.884428E 03	-0.299542E-01
34	0.880031E 03	0.870840E 03	0.104442E-01
35	0.815779E 03	0.790581E 03	0.308879E-01
36	0.811852E 03	0.792843E 03	0.234146E-01
37	0.823344E 03	0.863005E 03	-0.481711E-01
38	0.712566E 03	0.738771E 03	-0.367747E-01
39	0.505647E 03	0.492362E 03	0.262746E-01
40	0.347764E 03	0.361684E 03	-0.400259E-01
41	0.320229E 03	0.317467E 03	0.862433E-02
42	0.342127E 03	0.325307E 03	0.491648E-01
43	0.331912E 03	0.345527E 03	-0.410208E-01
44	0.335299E 03	0.334081E 03	0.363225E-02
45	0.310111E 03	0.297365E 03	0.411010E-01
46	0.282176E 03	0.270754E 03	0.404790E-01
47	0.241830E 03	0.258708E 03	-0.697953E-01
48	0.259000E 03	0.258740E 03	0.100228E-02
49	0.251618E 03	0.249017E 03	0.103351E-01
50	0.285340E 03	0.252307E 03	0.115769E-00
51	0.230852E 03	0.255380E 03	-0.106253E-00
52	0.263485E 03	0.274641E 03	-0.423375E-01
53	0.282081E 03	0.295394E 03	-0.471986E-01
54	0.341405E 03	0.318460E 03	0.672063E-01
55	0.457604E 03	0.363006E 03	0.206724E-00
56	0.515214E 03	0.439703E 03	0.146564E-00
57	0.522143E 03	0.528164E 03	-0.115316E-01
58	0.468580E 03	0.554659E 03	-0.183703E-00
59	0.460494E 03	0.503472E 03	-0.933299E-01
60	0.421930E 03	0.384667E 03	0.883140E-01
61	0.308223E 03	0.296856E 03	0.368789E-01
62	0.286944E 03	0.240421E 03	0.162134E-00
63	0.231216E 03	0.214220E 03	0.735096E-01
64	0.194676E 03	0.206350E 03	-0.599671E-01
65	0.205290E 03	0.210631E 03	-0.260158E-01
66	0.192295E 03	0.197850E 03	-0.288861E-01
67	0.214335E 03	0.207241E 03	0.330949E-01
68	0.193902E 03	0.204535E 03	-0.548399E-01
69	0.207026E 03	0.203203E 03	0.184682E-01
70	0.220220E 03	0.228810E 03	-0.390085E-01

71	0.240554E 03	0.247236E 03	-0.277810E-01
72	0.256067E 03	0.282012E 03	-0.101319E-00
73	0.288966E 03	0.304826E 03	-0.548857E-01
74	0.326907E 03	0.319396E 03	0.229770E-01
75	0.317490E 03	0.298541E 03	0.596830E-01
76	0.280306E 03	0.255385E 03	0.889050E-01
77	0.232483E 03	0.203791E 03	0.123415E-00
78	0.208559E 03	0.187874E 03	0.991811E-01
79	0.186773E 03	0.171740E 03	0.804882E-01
80	0.180865E 03	0.180611E 03	0.140774E-02
81	0.174302E 03	0.181722E 03	-0.425739E-01
82	0.174970E 03	0.181189E 03	-0.355427E-01
83	0.177677E 03	0.182195E 03	-0.254294E-01
84	0.176593E 03	0.168638E 03	0.450457E-01
85	0.170298E 03	0.193979E 03	-0.139055E-00
86	0.185152E 03	0.207603E 03	-0.121256E-00
87	0.220804E 03	0.221234E 03	-0.194921E-02
88	0.268865E 03	0.244938E 03	0.889939E-01
89	0.324217E 03	0.307156E 03	0.526212E-01
90	0.377872E 03	0.366368E 03	0.304429E-01
91	0.391293E 03	0.400100E 03	-0.225076E-01
92	0.376481E 03	0.381777E 03	-0.140688E-01
93	0.291349E 03	0.302006E 03	-0.365771E-01
94	0.190166E 03	0.203889E 03	-0.721614E-01
95	0.150323E 03	0.127079E 03	0.154627E-00
96	0.115534E 03	0.104675E 03	0.939959E-01
97	0.119578E 03	0.101869E 03	0.148097E-00
98	0.126326E 03	0.126443E 03	-0.927182E-03
99	0.181347E 03	0.167052E 03	0.788281E-01
100	0.233255E 03	0.228969E 03	0.183744E-01
101	0.269842E 03	0.281918E 03	-0.447518E-01
102	0.290676E 03	0.304817E 03	-0.486481E-01
103	0.279082E 03	0.286080E 03	-0.250771E-01
104	0.241048E 03	0.269328E 03	-0.117320E-00
105	0.207323E 03	0.230181E 03	-0.110257E-00
106	0.207239E 03	0.203343E 03	0.188004E-01
107	0.189472E 03	0.177002E 03	0.658150E-01
108	0.176863E 03	0.172292E 03	0.258459E-01
109	0.179645E 03	0.168789E 03	0.604292E-01
110	0.162277E 03	0.163346E 03	-0.658461E-02
111	0.151191E 03	0.155795E 03	-0.304557E-01
112	0.126995E 03	0.145182E 03	-0.143202E-00
113	0.111572E 03	0.113052E 03	-0.132613E-01
114	0.877659E 02	0.930152E 02	-0.598094E-01
115	0.748159E 02	0.750320E 02	-0.288811E-02
116	0.730084E 02	0.650052E 02	0.109620E-00
117	0.674159E 02	0.640449E 02	0.500027E-01
118	0.715883E 02	0.637288E 02	0.109787E-00
119	0.752247E 02	0.604409E 02	0.196528E-00
120	0.749689E 02	0.635023E 02	0.152951E-00
121	0.721368E 02	0.679509E 02	0.580274E-01
122	0.737623E 02	0.744212E 02	-0.893331E-02
123	0.669367E 02	0.773828E 02	-0.156059E-00
124	0.648597E 02	0.758675E 02	-0.169716E-00
125	0.585666E 02	0.713071E 02	-0.217538E-00
126	0.587276E 02	0.634971E 02	-0.812137E-01
127	0.568381E 02	0.579121E 02	-0.188970E-01
128	0.392697E 02	0.490563E 02	-0.249216E-00
129	0.389177E 02	0.494277E 02	-0.270056E-00
130	0.425316E 02	0.470675E 02	-0.106649E-00
131	0.343671E 02	0.372852E 02	-0.849093E-01
132	0.317157E 02	0.445067E 02	-0.403302E-00
133	0.397906E 02	0.429693E 02	-0.798837E-01
134	0.410583E 02	0.400734E 02	0.239885E-01
135	0.404672E 02	0.364402E 02	0.995122E-01
136	0.503406E 02	0.353733E 02	0.297320E-00

137	0.528980E 02	0.381457E 02	0.278882E-00
138	0.442808E 02	0.356841E 02	0.194139E-00
139	0.484045E 02	0.406753E 02	0.159680E-00
140	0.668379E 02	0.488434E 02	0.269226E-00
141	0.809842E 02	0.659065E 02	0.186181E-00
142	0.950219E 02	0.874212E 02	0.799885E-01
143	0.110702E 03	0.103998E 03	0.605597E-01
144	0.111142E 03	0.122082E 03	-0.984327E-01
145	0.114901E 03	0.128489E 03	-0.118259E-00
146	0.118613E 03	0.122240E 03	-0.305837E-01
147	0.108030E 03	0.110110E 03	-0.192515E-01
148	0.984375E 02	0.103168E 03	-0.480523E-01
149	0.873700E 02	0.995863E 02	-0.139823E-00
150	0.858651E 02	0.815966E 02	0.497113E-01
151	0.751036E 02	0.690601E 02	0.804699E-01
152	0.688177E 02	0.688554E 02	-0.548042E-03
153	0.655599E 02	0.536798E 02	0.181209E-00
154	0.572714E 02	0.422932E 02	0.261530E-00
155	0.444258E 02	0.451179E 02	-0.155779E-01
156	0.363138E 02	0.422463E 02	-0.163370E-00
157	0.345480E 02	0.462104E 02	-0.337572E-00
158	0.475121E 02	0.428493E 02	0.981410E-01
159	0.325213E 02	0.419330E 02	-0.289400E-00
160	0.498522E 02	0.343195E 02	0.311574E-00
161	0.408569E 02	0.434229E 02	-0.628035E-01
162	0.234448E 02	0.391551E 02	-0.670095E 00
163	0.436278E 02	0.408251E 02	0.642430E-01
164	0.444175E 02	0.321479E 02	0.276234E-00
165	0.365329E 02	0.340794E 02	0.671573E-01
166	0.359186E 02	0.348594E 02	0.294870E-01
167	0.273351E 02	0.307157E 02	-0.123673E-00
168	0.266218E 02	0.245401E 02	0.781954E-01
169	0.209388E 02	0.196808E 02	0.600810E-01
170	0.241881E 02	0.183544E 02	0.241181E-00
171	0.117721E 02	0.142520E 02	-0.210658E-00
172	0.155455E 02	0.151155E 02	0.276609E-01
173	0.125375E 02	0.116476E 02	0.709754E-01
174	0.118516E 02	0.105505E 02	0.109784E-00
175	0.143478E 02	0.115688E 02	0.193687E-00
176	0.143329E 02	0.990265E 01	0.309095E-00
177	0.236749E 02	0.219650E 02	0.722241E-01
178	0.365216E 02	0.304848E 02	0.165293E-00
179	0.511867E 02	0.473484E 02	0.749848E-01
180	0.629119E 02	0.625885E 02	0.514096E-02
181	0.957252E 02	0.886207E 02	0.742172E-01
182	0.107270E 03	0.106089E 03	0.110058E-01
183	0.110627E 03	0.121380E 03	-0.971968E-01
184	0.108678E 03	0.112948E 03	-0.392936E-01
185	0.101658E 03	0.975381E 02	0.405247E-01
186	0.810277E 02	0.749638E 02	0.748379E-01
187	0.501123E 02	0.649314E 02	-0.295718E-00
188	0.368007E 02	0.450699E 02	-0.224704E-00
189	0.245162E 02	0.253054E 02	-0.321927E-01
190	0.146436E 02	0.172117E 02	-0.175369E-00
191	0.104575E 02	0.834835E 01	0.201690E-00
192	0.639648E 01	0.516470E 01	0.192572E-00
193	0.326136E 01	0.254666E 01	0.219143E-00
194	0.193525E 01	0.227992E 01	-0.178099E-00
195	0.132623E 01	0.127835E 01	0.361004E-01
196	0.921793E 00	0.107480E 01	-0.165988E-00

GAIN SHIFT OF 0.98187 GIVES CHI SQUARE VALUE 0.147630E 01

SPECTRUM ZERO SEARCH FROM -2.00 TO 2.00

ZERO DRIFT OF -2.00000 GIVES CHI SQUARE VALUE 0.242152E 02

ZERO DRIFT OF 2.00000 GIVES CHI SQUARE VALUE 0.144597E 02

ZERO DRIFT OF 0. GIVES CHI SQUARE VALUE 0.147630E 01

ZERO DRIFT OF -1.00000 GIVES CHI SQUARE VALUE 0.120586E 02

ZERO DRIFT OF 1.00000 GIVES CHI SQUARE VALUE 0.564009E 01

ZERO DRIFT OF -0.50000 GIVES CHI SQUARE VALUE 0.215392E 01

ZERO DRIFT OF 0.50000 GIVES CHI SQUARE VALUE 0.242544E 01

ZERO DRIFT OF -0.25000 GIVES CHI SQUARE VALUE 0.154706E 01

ZERO DRIFT OF 0.25000 GIVES CHI SQUARE VALUE 0.164467E 01

ZERO DRIFT OF -0.12500 GIVES CHI SQUARE VALUE 0.145016E 01

ZERO DRIFT OF -0.06250 GIVES CHI SQUARE VALUE 0.144531E 01

ZERO DRIFT OF -0.09375 GIVES CHI SQUARE VALUE 0.143919E 01

ZERO DRIFT OF -0.07813 GIVES CHI SQUARE VALUE 0.144113E 01

ZERO DRIFT OF -0.10938 GIVES CHI SQUARE VALUE 0.144771E 01

ZERO DRIFT OF -0.08594 GIVES CHI SQUARE VALUE 0.143988E 01

ZERO DRIFT OF -0.10156 GIVES CHI SQUARE VALUE 0.143906E 01

ZERO DRIFT OF -0.09766 GIVES CHI SQUARE VALUE 0.143906E 01

USING FUNCTIONAL LIBRARY FROM CHANNEL 10 THROUGH 195

AND USING ELEMENTS NA CL K MN SC A AS CU CR I LA

RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
NA	0.196169E 02
CL	0.124593E 02
K	0.955038E 01
MN	0.440643E 01
SC	0.447429E 01
AS	0.107529E 02
CU	0.393782E 01
CR	0.478956E 01
I	0.924724E 00
LA	0.398962E 01

ELIMINATING ELEMENTS

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
10	0.120780E 04	0.115460E 04	0.440458E-01
11	0.117446E 04	0.111567E 04	0.500513E-01
12	0.109887E 04	0.112416E 04	-0.230150E-01
13	0.107264E 04	0.107678E 04	-0.386753E-02
14	0.109780E 04	0.110220E 04	-0.400313E-02
15	0.108390E 04	0.111636E 04	-0.299448E-01
16	0.105913E 04	0.107329E 04	-0.133640E-01
17	0.102294E 04	0.988442E 03	0.337217E-01
18	0.976994E 03	0.955828E 03	0.216647E-01
19	0.102501E 04	0.977654E 03	0.462034E-01
20	0.120051E 04	0.121302E 04	-0.104216E-01
21	0.131207E 04	0.138128E 04	-0.527465E-01
22	0.109160E 04	0.102942E 04	0.569642E-01
23	0.752010E 03	0.700451E 03	0.685613E-01
24	0.611230E 03	0.588701E 03	0.368584E-01
25	0.548298E 03	0.551764E 03	-0.632111E-02
26	0.514719E 03	0.531164E 03	-0.319490E-01
27	0.532397E 03	0.519272E 03	0.246531E-01
28	0.548128E 03	0.542852E 03	0.962480E-02
29	0.573215E 03	0.586137E 03	-0.225434E-01
30	0.597510E 03	0.604580E 03	-0.118326E-01
31	0.644626E 03	0.671873E 03	-0.422674E-01
32	0.768655E 03	0.801022E 03	-0.421078E-01
33	0.860783E 03	0.888922E 03	-0.326904E-01
34	0.873689E 03	0.874311E 03	-0.712065E-03
35	0.815330E 03	0.788946E 03	0.323600E-01
36	0.812945E 03	0.783037E 03	0.367898E-01
37	0.812518E 03	0.847804E 03	-0.434277E-01
38	0.692372E 03	0.726470E 03	-0.492482E-01
39	0.490220E 03	0.486737E 03	0.710612E-02
40	0.345062E 03	0.360130E 03	-0.436662E-01
41	0.322350E 03	0.316479E 03	0.182138E-01
42	0.341107E 03	0.323918E 03	0.503912E-01
43	0.332229E 03	0.343540E 03	-0.340479E-01
44	0.332823E 03	0.332118E 03	0.211991E-02
45	0.307376E 03	0.295998E 03	0.370181E-01
46	0.278248E 03	0.270043E 03	0.294900E-01
47	0.243493E 03	0.258375E 03	-0.611192E-01
48	0.258294E 03	0.258473E 03	-0.694682E-03
49	0.254910E 03	0.248894E 03	0.236000E-01
50	0.280006E 03	0.252172E 03	0.994056E-01
51	0.234035E 03	0.255310E 03	-0.909052E-01
52	0.265287E 03	0.274658E 03	-0.353247E-01
53	0.287867E 03	0.295636E 03	-0.269866E-01
54	0.352748E 03	0.318802E 03	0.962331E-01
55	0.463220E 03	0.363183E 03	0.215961E-00
56	0.515890E 03	0.439436E 03	0.148198E-00
57	0.516916E 03	0.527241E 03	-0.199747E-01
58	0.467786E 03	0.553011E 03	-0.182187E-00
59	0.456732E 03	0.501706E 03	-0.984712E-01
60	0.410824E 03	0.383322E 03	0.669434E-01
61	0.306129E 03	0.296292E 03	0.321316E-01
62	0.281503E 03	0.240286E 03	0.146416E-00
63	0.227646E 03	0.214189E 03	0.591144E-01
64	0.195706E 03	0.206254E 03	-0.538990E-01
65	0.204025E 03	0.210665E 03	-0.325487E-01
66	0.194442E 03	0.197936E 03	-0.179722E-01
67	0.212337E 03	0.207236E 03	0.240218E-01
68	0.195184E 03	0.204599E 03	-0.482394E-01
69	0.208315E 03	0.203271E 03	0.242163E-01
70	0.222201E 03	0.228693E 03	-0.292177E-01

71	0.242070E 03	0.246767E 03	-0.194048E-01
72	0.259276E 03	0.281209E 03	-0.845939E-01
73	0.292678E 03	0.303571E 03	-0.372178E-01
74	0.325980E 03	0.317939E 03	0.246656E-01
75	0.313866E 03	0.297289E 03	0.528148E-01
76	0.275632E 03	0.254712E 03	0.758975E-01
77	0.230135E 03	0.203452E 03	0.115945E-00
78	0.206431E 03	0.187761E 03	0.904441E-01
79	0.186187E 03	0.171579E 03	0.784562E-01
80	0.180222E 03	0.180384E 03	-0.896872E-03
81	0.174363E 03	0.181478E 03	-0.408023E-01
82	0.175229E 03	0.180970E 03	-0.327641E-01
83	0.177570E 03	0.182115E 03	-0.255920E-01
84	0.175980E 03	0.168743E 03	0.411231E-01
85	0.171743E 03	0.193998E 03	-0.129581E-00
86	0.188637E 03	0.207523E 03	-0.100121E-00
87	0.225490E 03	0.221151E 03	0.192432E-01
88	0.274271E 03	0.244649E 03	0.108004E-00
89	0.329454E 03	0.306563E 03	0.694834E-01
90	0.379184E 03	0.365590E 03	0.358494E-01
91	0.389852E 03	0.399195E 03	-0.239655E-01
92	0.368170E 03	0.380865E 03	-0.344812E-01
93	0.281478E 03	0.301305E 03	-0.704386E-01
94	0.186293E 03	0.203419E 03	-0.919333E-01
95	0.146940E 03	0.126841E 03	0.136781E-00
96	0.115931E 03	0.104574E 03	0.979629E-01
97	0.120233E 03	0.102005E 03	0.151607E-00
98	0.131670E 03	0.126843E 03	0.366563E-01
99	0.186399E 03	0.167999E 03	0.987162E-01
100	0.236812E 03	0.230521E 03	0.265646E-01
101	0.271868E 03	0.284044E 03	-0.447863E-01
102	0.289541E 03	0.307267E 03	-0.612221E-01
103	0.275367E 03	0.288403E 03	-0.473421E-01
104	0.237751E 03	0.271427E 03	-0.141643E-00
105	0.207317E 03	0.231803E 03	-0.118111E-00
106	0.205502E 03	0.204419E 03	0.527102E-02
107	0.188242E 03	0.177538E 03	0.568583E-01
108	0.177133E 03	0.172304E 03	0.272629E-01
109	0.177944E 03	0.168391E 03	0.536834E-01
110	0.161196E 03	0.162703E 03	-0.934647E-02
111	0.148827E 03	0.155087E 03	-0.420603E-01
112	0.125492E 03	0.144494E 03	-0.151425E-00
113	0.109245E 03	0.112506E 03	-0.298528E-01
114	0.865067E 02	0.925801E 02	-0.702072E-01
115	0.746303E 02	0.746949E 02	-0.865818E-03
116	0.724742E 02	0.647327E 02	0.106817E-00
117	0.678211E 02	0.637785E 02	0.596070E-01
118	0.719348E 02	0.634859E 02	0.117452E-00
119	0.751976E 02	0.602140E 02	0.199256E-00
120	0.746947E 02	0.633051E 02	0.152483E-00
121	0.722923E 02	0.677698E 02	0.625584E-01
122	0.730928E 02	0.742336E 02	-0.156084E-01
123	0.667355E 02	0.771604E 02	-0.156212E-00
124	0.642424E 02	0.756611E 02	-0.177744E-00
125	0.585828E 02	0.711060E 02	-0.213768E-00
126	0.585432E 02	0.632987E 02	-0.812297E-01
127	0.551217E 02	0.577145E 02	-0.470370E-01
128	0.392308E 02	0.489141E 02	-0.246831E-00
129	0.392727E 02	0.492479E 02	-0.253997E-00
130	0.417340E 02	0.468791E 02	-0.123283E-00
131	0.341071E 02	0.371589E 02	-0.894780E-01
132	0.325023E 02	0.443678E 02	-0.365067E-00
133	0.399203E 02	0.428331E 02	-0.729660E-01
134	0.409991E 02	0.399434E 02	0.257509E-01
135	0.414314E 02	0.363217E 02	0.123330E-00
136	0.505896E 02	0.352614E 02	0.302991E-00

137	0.520560E 02	0.379938E 02	0.270135E-00
138	0.446861E 02	0.355472E 02	0.204512E-00
139	0.502012E 02	0.405044E 02	0.193159E-00
140	0.682270E 02	0.486329E 02	0.287190E-00
141	0.823507E 02	0.656191E 02	0.203175E-00
142	0.965530E 02	0.870261E 02	0.986707E-01
143	0.110746E 03	0.103489E 03	0.655279E-01
144	0.111510E 03	0.121496E 03	-0.895584E-01
145	0.115259E 03	0.127860E 03	-0.109321E-00
146	0.117578E 03	0.121648E 03	-0.346142E-01
147	0.107093E 03	0.109592E 03	-0.233348E-01
148	0.973552E 02	0.102716E 03	-0.550616E-01
149	0.872251E 02	0.991987E 02	-0.137272E-00
150	0.848146E 02	0.813032E 02	0.414019E-01
151	0.744870E 02	0.688141E 02	0.761594E-01
152	0.684945E 02	0.686196E 02	-0.182618E-02
153	0.647530E 02	0.535137E 02	0.173572E-00
154	0.560171E 02	0.421848E 02	0.246929E-00
155	0.436340E 02	0.450076E 02	-0.314809E-01
156	0.361407E 02	0.421387E 02	-0.165964E-00
157	0.358142E 02	0.460856E 02	-0.286796E-00
158	0.460472E 02	0.427329E 02	0.719763E-01
159	0.342135E 02	0.418223E 02	-0.222393E-00
160	0.489733E 02	0.342288E 02	0.301071E-00
161	0.391544E 02	0.433109E 02	-0.106157E-00
162	0.254187E 02	0.390550E 02	-0.536466E 00
163	0.437046E 02	0.407345E 02	0.679591E-01
164	0.436436E 02	0.320799E 02	0.264959E-00
165	0.364753E 02	0.340097E 02	0.675961E-01
166	0.350810E 02	0.347962E 02	0.811735E-02
167	0.272646E 02	0.306688E 02	-0.124859E-00
168	0.260675E 02	0.245007E 02	0.601060E-01
169	0.212581E 02	0.196504E 02	0.756260E-01
170	0.229801E 02	0.183238E 02	0.202626E-00
171	0.121393E 02	0.142337E 02	-0.172530E-00
172	0.152609E 02	0.150854E 02	0.114952E-01
173	0.124614E 02	0.116226E 02	0.673111E-01
174	0.120963E 02	0.105257E 02	0.129842E-00
175	0.143410E 02	0.115342E 02	0.195722E-00
176	0.152445E 02	0.987821E 01	0.352016E-00
177	0.249276E 02	0.219022E 02	0.121367E-00
178	0.379527E 02	0.303968E 02	0.199088E-00
179	0.523322E 02	0.472100E 02	0.978779E-01
180	0.661153E 02	0.624032E 02	0.561466E-01
181	0.968511E 02	0.883607E 02	0.876643E-01
182	0.107600E 03	0.105780E 03	0.169143E-01
183	0.110435E 03	0.121025E 03	-0.958881E-01
184	0.107991E 03	0.112620E 03	-0.428588E-01
185	0.996423E 02	0.972581E 02	0.239279E-01
186	0.780098E 02	0.747468E 02	0.418283E-01
187	0.488114E 02	0.647455E 02	-0.326443E-00
188	0.356013E 02	0.449414E 02	-0.262352E-00
189	0.235514E 02	0.252351E 02	-0.714893E-01
190	0.142351E 02	0.171646E 02	-0.205793E-00
191	0.100593E 02	0.832810E 01	0.172101E-00
192	0.609259E 01	0.515005E 01	0.154704E-00
193	0.313088E 01	0.253924E 01	0.188971E-00
194	0.187561E 01	0.227217E 01	-0.211427E-00
195	0.128641E 01	0.127409E 01	0.957207E-02

```
ZERO DRIFT OF  -0.09766   GIVES CHI SQUARE VALUE   0.143906E 01

CORRELATION MATRIX          STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
                            OFF DIAGONAL ELEMENT = CROSS CORRELATION

ROW   1

    0.63008E 00

ROW   2

    0.15200E-00     0.76005E 00

ROW   3

    0.69204E-02     0.51814E-02     0.60313E 00

ROW   4

    0.51032E-02     0.40705E-01     0.12488E-02     0.63620E 00

ROW   5

    0.47664E-02     0.13408E-01     0.10546E-01     0.38614E-00     0.48960E-00

ROW   6

    0.20080E-02     0.11579E-02     0.10571E-01     0.63738E-02     0.87167E-02     0.62598E 00

ROW   7

    0.21598E-02     0.36347E-02     0.16348E-01     0.52421E-04     0.98222E-03     0.58950E-01     0.55326E 00

ROW   8

    0.29814E-03     0.41359E-02     0.83830E-02     0.12420E-03     0.56422E-03     0.14902E-01     0.77290E-03
    0.42398E-00

ROW   9

    0.14585E-04     0.27474E-02     0.56896E-02     0.25899E-03     0.27606E-03     0.14790E-01     0.61175E-02
    0.77263E-03     0.34083E-00

ROW  10

    0.18536E-02     0.50637E-01     0.22818E-00     0.68076E-02     0.18106E-01     0.28301E-04     0.12984E-00
    0.10651E-00     0.75790E-01     0.41726E-00
```

RESULTS OF FLOW 1
PROBLEM 1

LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA

FUNCTION LIBRARY GAMAGA OF 11 ELEMENTS AND 191 CHANNELS,STARTING WITH CHANNEL, 10

SPECTRUM TO BE ANALYZED LAST OF 186 CHANNELS,STARTING WITH CHANNEL, 10

FLOW OPTION 1 ITERATIVE MODE

COMPONENT TO BE SUBTRACTED NA BETA OF 18.73000 ERROR OF 0.13400

COMPONENT TO BE SUBTRACTED SC BETA OF 4.83100 ERROR OF 0.13000

COMPONENT TO BE SUBTRACTED LA BETA OF 3.41200 ERROR OF 0.15900

USING FUNCTIONAL LIBRARY FROM CHANNEL 10 THROUGH 195

AND USING ELEMENTS NA CL K MN SC A AS CU CR I LA

RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
CL	0.131559E 02
K	0.999596E 01
MN	0.437442E 01
AS	0.107693E 02
CU	0.425964E 01
CR	0.497508E 01
I	0.105031E 01

ELIMINATING ELEMENTS

NA

SC

A

LA

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
10	0.833089E 03	0.785668E 03	0.569225E-01
11	0.796482E 03	0.740899E 03	0.697856E-01
12	0.719693E 03	0.746882E 03	-0.377779E-01
13	0.686491E 03	0.691457E 03	-0.723366E-02
14	0.674178E 03	0.679960E 03	-0.857584E-02
15	0.646547E 03	0.678759E 03	-0.498213E-01
16	0.635667E 03	0.649368E 03	-0.215535E-01
17	0.635720E 03	0.600434E 03	0.555067E-01
18	0.608876E 03	0.586955E 03	0.360029E-01
19	0.670586E 03	0.624193E 03	0.691821E-01
20	0.833355E 03	0.850671E 03	-0.207782E-01
21	0.900219E 03	0.968202E 03	-0.755188E-01
22	0.724745E 03	0.654675E 03	0.966816E-01
23	0.471911E 03	0.417167E 03	0.116004E-00
24	0.363349E 03	0.340037E 03	0.641567E-01
25	0.315217E 03	0.318632E 03	-0.108338E-01
26	0.283216E 03	0.298554E 03	-0.541588E-01
27	0.304966E 03	0.290887E 03	0.461661E-01
28	0.324909E 03	0.322697E 03	0.680687E-02
29	0.332508E 03	0.350398E 03	-0.538050E-01
30	0.330273E 03	0.335401E 03	-0.155254E-01
31	0.299545E 03	0.307591E 03	-0.268611E-01
32	0.363213E 03	0.372939E 03	-0.267765E-01
33	0.483187E 03	0.506008E 03	-0.472290E-01
34	0.571740E 03	0.584368E 03	-0.220880E-01
35	0.573636E 03	0.558295E 03	0.267432E-01
36	0.629022E 03	0.603856E 03	0.400074E-01
37	0.639552E 03	0.674741E 03	-0.550206E-01
38	0.520321E 03	0.553351E 03	-0.634800E-01
39	0.329725E 03	0.326327E 03	0.103036E-01
40	0.182360E 03	0.197400E 03	-0.824739E-01
41	0.163100E 03	0.157100E 03	0.367891E-01
42	0.183889E 03	0.167395E 03	0.896934E-01
43	0.175563E 03	0.187338E 03	-0.670691E-01
44	0.181251E 03	0.180722E 03	0.291532E-02
45	0.170856E 03	0.159649E 03	0.655944E-01
46	0.140493E 03	0.131658E 03	0.628860E-01
47	0.104003E 03	0.117437E 03	-0.129161E-00
48	0.119786E 03	0.118707E 03	0.900586E-02
49	0.118769E 03	0.110540E 03	0.692812E-01
50	0.140737E 03	0.110599E 03	0.214147E-00
51	0.895385E 02	0.107277E 03	-0.198110E-00
52	0.109321E 03	0.113327E 03	-0.366499E-01
53	0.114301E 03	0.113884E 03	0.364440E-02
54	0.175572E 03	0.132721E 03	0.244064E-00
55	0.284165E 03	0.178413E 03	0.372152E-00
56	0.315054E 03	0.237162E 03	0.247236E-00
57	0.269437E 03	0.283453E 03	-0.520166E-01
58	0.172951E 03	0.266790E 03	-0.542575E 00
59	0.158993E 03	0.213005E 03	-0.339709E-00
60	0.167309E 03	0.144641E 03	0.135484E-00
61	0.125820E 03	0.116536E 03	0.737858E-01
62	0.146507E 03	0.102440E 03	0.300786E-00
63	0.117202E 03	0.101363E 03	0.135146E-00
64	0.943161E 02	0.102935E 03	-0.913844E-01
65	0.102162E 03	0.107090E 03	-0.482325E-01
66	0.948044E 02	0.963859E 02	-0.166828E-01
67	0.109653E 03	0.102862E 03	0.619293E-01
68	0.969690E 02	0.105066E 03	-0.835028E-01
69	0.106982E 03	0.100774E 03	0.580316E-01
70	0.960938E 02	0.101293E 03	-0.541078E-01

71	0.929914E 02	0.982306E 02	-0.563401E-01
72	0.740802E 02	0.993142E 02	-0.340631E-00
73	0.790093E 02	0.963879E 02	-0.219956E-00
74	0.102272E 03	0.102185E 03	0.852544E-03
75	0.111909E 03	0.101638E 03	0.917869E-01
76	0.124598E 03	0.107296E 03	0.138867E-00
77	0.129726E 03	0.105121E 03	0.189671E-00
78	0.128985E 03	0.110401E 03	0.144077E-00
79	0.127112E 03	0.112122E 03	0.117925E-00
80	0.124373E 03	0.124258E 03	0.927800E-03
81	0.116754E 03	0.123336E 03	-0.563693E-01
82	0.121526E 03	0.127033E 03	-0.453156E-01
83	0.122496E 03	0.126780E 03	-0.349756E-01
84	0.129347E 03	0.122276E 03	0.546626E-01
85	0.106976E 03	0.129079E 03	-0.206613E-00
86	0.108864E 03	0.127048E 03	-0.167037E-00
87	0.124671E 03	0.118312E 03	0.510101E-01
88	0.139623E 03	0.106167E 03	0.239618E-00
89	0.127655E 03	0.975542E 02	0.235796E-00
90	0.110625E 03	0.865331E 02	0.217782E-00
91	0.843469E 02	0.813317E 02	0.357477E-01
92	0.754893E 02	0.763542E 02	-0.114575E-01
93	0.554800E 02	0.665119E 02	-0.198845E-00
94	0.415719E 02	0.532783E 02	-0.281593E-00
95	0.734230E 02	0.512163E 02	0.302448E-00
96	0.674614E 02	0.554541E 02	0.177989E-00
97	0.915846E 02	0.745159E 02	0.186370E-00
98	0.104363E 03	0.102016E 03	0.224911E-01
99	0.160539E 03	0.146424E 03	0.879199E-01
100	0.207529E 03	0.207979E 03	-0.216787E-02
101	0.234265E 03	0.253801E 03	-0.833913E-01
102	0.237555E 03	0.260062E 03	-0.947442E-01
103	0.202873E 03	0.215298E 03	-0.612452E-01
104	0.139765E 03	0.166565E 03	-0.191754E-00
105	0.989232E 02	0.112553E 03	-0.137778E-00
106	0.100023E 03	0.877713E 02	0.122487E-00
107	0.101420E 03	0.824790E 02	0.186755E-00
108	0.112920E 03	0.104730E 03	0.725297E-01
109	0.133063E 03	0.124484E 03	0.644689E-01
110	0.127309E 03	0.132540E 03	-0.410897E-01
111	0.115679E 03	0.126070E 03	-0.898256E-01
112	0.867807E 02	0.109033E 03	-0.256421E-00
113	0.713661E 02	0.764631E 02	-0.714217E-01
114	0.529558E 02	0.602417E 02	-0.137583E-00
115	0.410064E 02	0.412468E 02	-0.586337E-02
116	0.404401E 02	0.325507E 02	0.195087E-00
117	0.349262E 02	0.305005E 02	0.126718E-00
118	0.405473E 02	0.318225E 02	0.215177E-00
119	0.497016E 02	0.346598E 02	0.302641E-00
120	0.499813E 02	0.385660E 02	0.228392E-00
121	0.465174E 02	0.417942E 02	0.101536E-00
122	0.474177E 02	0.485181E 02	-0.232055E-01
123	0.389355E 02	0.492314E 02	-0.264436E-00
124	0.375404E 02	0.489127E 02	-0.302936E-00
125	0.308768E 02	0.432473E 02	-0.400641E-00
126	0.301862E 02	0.346715E 02	-0.148589E-00
127	0.290615E 02	0.314769E 02	-0.831124E-01
128	0.113193E 02	0.202887E 02	-0.792406E 00
129	0.106725E 02	0.200662E 02	-0.880174E 00
130	0.131198E 02	0.175583E 02	-0.338305E-00
131	0.118320E 02	0.142796E 02	-0.206867E-00
132	0.181069E-00	0.108634E 02	-0.589960E 02
133	0.953365E 01	0.114151E 02	-0.197353E-00
134	0.126893E 02	0.106407E 02	0.161441E-00
135	0.133736E 02	0.717872E 01	0.463219E-00
136	0.241935E 02	0.785842E 01	0.675185E 00

137	0.243339E 02	0.914642E 01	0.624128E 00
138	0.215050E 02	0.115888E 02	0.461113E-00
139	0.255650E 02	0.151511E 02	0.407349E-00
140	0.457156E 02	0.258644E 02	0.434233E-00
141	0.553547E 02	0.388477E 02	0.298204E-00
142	0.680380E 02	0.596556E 02	0.123202E-00
143	0.852816E 02	0.803192E 02	0.581882E-01
144	0.822346E 02	0.951801E 02	-0.157423E-00
145	0.844607E 02	0.100343E 03	-0.188040E-00
146	0.873616E 02	0.944709E 02	-0.813780E-01
147	0.766919E 02	0.816577E 02	-0.647493E-01
148	0.501764E 02	0.559761E 02	-0.115587E-00
149	0.281301E 02	0.390988E 02	-0.389929E-00
150	0.268574E 02	0.215846E 02	0.196326E-00
151	0.203390E 02	0.126068E 02	0.380167E-00
152	0.121206E 02	0.990863E 01	0.182495E-00
153	0.176683E 02	0.428312E 01	0.757582E 00
154	0.180187E 02	0.236610E 01	0.868687E 00
155	0.261884E 01	0.197044E 01	0.247590E-00
156	-0.278848E 01	0.131363E 01	0.147109E 01
157	-0.614837E 01	0.214738E 01	0.134926E 01
158	0.605156E 01	0.831792E 00	0.862549E 00
159	-0.386068E 01	0.192768E 01	0.149931E 01
160	0.175169E 02	0.127021E 01	0.927486E 00
161	-0.483876E-00	0.175238E 01	0.462154E 01
162	-0.103204E 02	0.157740E 01	0.115284E 01
163	0.544675E 01	0.481512E-00	0.911596E 00
164	0.140815E 02	0.963676E 00	0.931564E 00
165	0.548460E 01	0.140144E 01	0.744476E 00
166	0.308822E 01	0.105051E 01	0.659833E 00
167	-0.185360E-00	0.166456E 01	0.998016E 01
168	0.378095E 01	0.963024E 00	0.745295E 00
169	0.397528E 01	0.140144E 01	0.647460E 00
170	0.733545E 01	0.183889E 01	0.749315E 00
171	-0.373358E-01	0.135705E 01	0.373471E 02
172	0.236985E 01	0.153300E 01	0.353121E-00
173	0.239728E 01	0.105149E 01	0.561382E 00
174	0.293534E 01	0.919280E 00	0.686823E 00
175	0.408188E 01	0.832444E 00	0.796064E 00
176	0.676772E 01	0.100644E 01	0.851288E 00
177	0.474161E 01	0.788047E 00	0.833802E 00
178	0.101298E 02	0.131363E 01	0.870320E 00
179	0.783954E 01	0.656815E 00	0.916218E 00
180	0.761755E 01	0.122679E 01	0.838952E 00
181	0.132068E 02	0.832118E 00	0.936993E 00
182	0.794443E 01	0.148926E 01	0.812541E 00
183	-0.322530E 01	0.210266E 01	0.165193E 01
184	0.173793E 01	0.140177E 01	0.193424E-00
185	0.860857E 01	0.197044E 01	0.771107E 00
186	0.837657E 01	0.188361E 01	0.775134E 00
187	-0.120611E 02	0.100709E 01	0.108350E 01
188	-0.645047E 01	0.919280E 00	0.114251E 01
189	0.326195E-00	0.919280E 00	-0.181819E 01
190	-0.112345E 01	0.109458E 01	0.197430E 01
191	0.294192E 01	0.875210E 00	0.702504E 00
192	0.178469E 01	0.657141E 00	0.631790E 00
193	0.107058E 01	0.394350E-00	0.631649E 00
194	0.141605E-00	0.482164E-00	-0.240500E 01
195	0.349908E-00	0.306862E-00	0.123023E-00

```
CHI SQUARE VALUE   0.147104E 01

CORRELATION MATRIX          STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
                            OFF DIAGONAL ELEMENT = CROSS CORRELATION

ROW   1

    0.68318E 00

ROW   2

    0.77112E-01     0.52265E 00

ROW   3

    0.10253E-00     0.38161E-01     0.48860E-00

ROW   4

    0.28873E-02     0.22481E-01     0.38665E-01     0.63095E 00

ROW   5

    0.28706E-02     0.47246E-02     0.63497E-02     0.72802E-01     0.52285E 00

ROW   6

    0.63149E-04     0.70168E-02     0.16217E-02     0.17770E-01     0.10517E-01     0.40691E-00

ROW   7

    0.12474E-03     0.66152E-02     0.10727E-01     0.18141E-01     0.40271E-01     0.48897E-02     0.33248E-00
```

EXHIBIT C
DATA CARD LISTING AND COMPUTER PRINTOUT FOR PROBLEM 2

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PROBLEM 2

INPUT DATA CARDS FOR FLOW 2 AND FLOW 3

```
LIBRARY   GAMT1  255     3    1    0
NA 22
      300.00  11780.00  21555.00  22153.00  21354.00  20853.00  19747.00
    19704.00  21338.00  21573.00  20453.00  18960.00  18672.00  18587.00
    18326.00  17963.00  17734.00  17512.00  17133.00  17007.00  16805.00
    16804.00  17074.00  17381.00  17015.00  16340.00  14433.00  12457.00
    10317.00   8789.00   7667.00   6990.00   6550.00   6277.00   5887.00
     5683.00   5491.00   5382.00   5221.00   5318.00   5623.00   6264.00
     8882.00  16477.00  32207.00  58384.00  91584.00 119617.00 128432.00
   113077.00  81140.00  48697.00  25837.00  13232.00   7270.00   4830.00
     3803.00   3277.00   3067.00   2994.00   3024.00   2865.00   2871.00
     2833.00   2894.00   2898.00   2903.00   2892.00   2916.00   2884.00
     2987.00   2966.00   3044.00   3004.00   3080.00   3128.00   3213.00
     3153.00   3194.00   3212.00   3089.00   3121.00   3241.00   3207.00
     3238.00   3314.00   3408.00   3379.00   3507.00   3582.00   3602.00
     3616.00   3657.00   3657.00   3903.00   3844.00   4057.00   4072.00
     4138.00   4132.00   4130.00   4087.00   3853.00   3554.00   3282.00
     2894.00   2490.00   2228.00   1951.00   1576.00   1378.00   1193.00
     1025.00    919.00    793.00    716.00    637.00    605.00    753.00
      996.00   1556.00   2385.00   3773.00   5741.00   8627.00  11669.00
    15515.00  17870.00  19456.00  19395.00  17459.00  15058.00  11927.00
     9086.00   6392.00   4349.00   2967.00   1939.00   1321.00    939.00
      612.00    423.00    353.00    279.00    246.00    203.00    184.00
      173.00    191.00    186.00    177.00    214.00    160.00    184.00
      175.00    187.00    176.00    160.00    173.00    131.00    131.00
      113.00    103.00     94.00    101.00     89.00     56.00     56.00
       59.00     39.00     69.00     58.00     47.00     57.00     85.00
      107.00    139.00    207.00    235.00    285.00    364.00    350.00
      415.00    313.00    342.00    225.00    198.00    144.00    118.00
       75.00     55.00     46.00     32.00     19.00     11.00      0.00
*  CS137
       13.00   1059.00   3569.00   3517.00   3491.00   3561.00   3134.00
     3135.00   3064.00   3016.00   3242.00   3435.00   3564.00   3399.00
     3160.00   2983.00   2931.00   3011.00   2891.00   2870.00   2777.00
     2783.00   2848.00   2836.00   2630.00   2616.00   2546.00   2591.00
     2453.00   2529.00   2387.00   2365.00   2334.00   2333.00   2352.00
     2498.00   2510.00   2638.00   2547.00   2586.00   2630.00   2654.00
     2548.00   2399.00   2090.00   1744.00   1382.00   1152.00    902.00
      738.00    623.00    546.00    477.00    424.00    411.00    392.00
      352.00    328.00    385.00    364.00    445.00    828.00   1329.00
     2681.00   5262.00   9063.00  13768.00  18611.00  21529.00  21826.00
    18451.00  13516.00   8511.00   4560.00   2475.00   1181.00    483.00
      205.00    111.00     60.00     12.00
*  CO 57
      113.00   4499.00  24686.00  52239.00 128745.00 243429.00  56936.00
     9201.00    594.00     93.00


SPECTRUM  GAMMA9 255         1    1    1
      360.00   4281.00   8451.00   9481.00  25247.00  48406.00  17405.00
     5859.00   3423.00   3047.00   3099.00   3009.00   2763.00   2621.00
     2589.00   2641.00   2501.00   2476.00   2505.00   2506.00   2404.00
     2401.00   2292.00   2304.00   2267.00   2308.00   2211.00   2150.00
     1991.00   1760.00   1657.00   1448.00   1402.00   1258.00   1289.00
     1155.00   1168.00   1072.00   1079.00   1059.00   1119.00   1122.00
```

* BLANK CARDS MUST BE ADDED TO GIVE THE PROPER NUMBER OF DATA POINTS FOR THESE TWO ELEMENTS

1049.00	1119.00	1101.00	1354.00	2061.00	3620.00	5962.00
9171.00	11606.00	12322.00	11052.00	8227.00	5220.00	2953.00
1515.00	947.00	604.00	526.00	471.00	494.00	609.00
836.00	1387.00	2156.00	3096.00	3983.00	4511.00	4544.00
3908.00	2963.00	2053.00	1324.00	891.00	571.00	440.00
391.00	349.00	350.00	371.00	329.00	370.00	342.00
319.00	321.00	307.00	317.00	316.00	317.00	318.00
315.00	334.00	363.00	362.00	352.00	377.00	360.00
365.00	413.00	380.00	419.00	406.00	426.00	398.00
405.00	398.00	391.00	382.00	351.00	290.00	263.00
225.00	179.00	190.00	164.00	138.00	107.00	93.00
95.00	87.00	87.00	86.00	76.00	68.00	72.00
111.00	160.00	222.00	348.00	567.00	789.00	1016.00
1400.00	1601.00	1792.00	1880.00	1778.00	1589.00	1297.00
1063.00	731.00	502.00	348.00	217.00	173.00	103.00
91.00	42.00	47.00	39.00	38.00	33.00	31.00
33.00	26.00	32.00	26.00	23.00	26.00	31.00
19.00	19.00	27.00	15.00	23.00	12.00	14.00
16.00	15.00	17.00	6.00	5.00	18.00	13.00
14.00	7.00	14.00	9.00	11.00	8.00	6.00
10.00	12.00	18.00	18.00	12.00	25.00	32.00
28.00	45.00	40.00	35.00	37.00	32.00	19.00
23.00	24.00	8.00	9.00	7.00	8.00	8.00
2.00	5.00	1.00	4.00	2.00	3.00	2.00
1.00	5.00	3.00	3.00	2.00	0	2.00
1.00	2.00	4.00	3.00	1.00	1.00	3.00
2.00	3.00	2.00	1.00	3.00	1.00	4.00
2.00	4.00	0	2.00	1.00	2.00	2.00
0	3.00	1.00	0	3.00	1.00	1.00
1.00	2.00	2.00	3.00	0	0	2.00
0	0	2.00	-1.00	-1.00	-1.00	-1.00
FLOW	2	1 1	3 255			
BACKGROUND	255	1	0 0	2.0	800.0	
793.00	120733.00	237373.00	238672.00	222644.00	209432.00	186313.00
165033.00	146135.00	131834.00	120363.00	111999.00	103058.00	93997.00
86282.00	81280.00	79296.00	78916.00	75727.00	68100.00	60199.00
53981.00	50958.00	50005.00	49749.00	47483.00	43943.00	39690.00
37252.00	37073.00	38829.00	40987.00	39540.00	35926.00	30743.00
26300.00	22824.00	21381.00	19971.00	18978.00	18289.00	17555.00
16955.00	16762.00	16324.00	16103.00	15553.00	15580.00	15428.00
15610.00	16033.00	15862.00	15063.00	14397.00	13122.00	12737.00
12271.00	12636.00	13590.00	14896.00	16334.00	18146.00	18597.00
18525.00	17232.00	15022.00	12910.00	11523.00	10267.00	9573.00
8747.00	8349.00	7611.00	7277.00	7054.00	7007.00	6769.00
6844.00	6874.00	6670.00	6849.00	6975.00	6937.00	6602.00
6273.00	6102.00	5777.00	5554.00	5498.00	5489.00	5083.00
5122.00	5127.00	5176.00	5354.00	5474.00	5346.00	5571.00
5447.00	5611.00	5561.00	5516.00	5113.00	4996.00	4843.00
4686.00	4371.00	4046.00	3906.00	3760.00	3484.00	3409.00
3366.00	3439.00	3321.00	3599.00	3770.00	4041.00	4248.00
4514.00	4625.00	4503.00	4330.00	4234.00	3874.00	3719.00
3413.00	3221.00	3043.00	3079.00	2960.00	2903.00	2930.00
2859.00	2816.00	2767.00	2593.00	2508.00	2314.00	2220.00
2193.00	2158.00	2209.00	2175.00	2176.00	2326.00	2394.00
2489.00	2564.00	2709.00	3024.00	3236.00	3285.00	3817.00
4149.00	4186.00	4217.00	4234.00	4045.00	3646.00	3257.00
2937.00	2616.00	2395.00	2117.00	1859.00	1765.00	1665.00
1524.00	1464.00	1395.00	1286.00	1334.00	1232.00	1122.00
1184.00	1198.00	1159.00	1199.00	1198.00	1324.00	1424.00
1399.00	1620.00	1789.00	1847.00	1859.00	1889.00	1864.00
1816.00	1656.00	1532.00	1379.00	1256.00	1149.00	1146.00

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   1093.00   1021.00    952.00    857.00    856.00    761.00    708.00
    701.00    649.00    635.00    643.00    601.00    629.00    572.00
    570.00    539.00    547.00    582.00    597.00    648.00    629.00
    643.00    679.00    724.00    755.00    801.00    799.00    818.00
    767.00    803.00    809.00    778.00    860.00    848.00    845.00
    825.00    699.00    731.00    716.00    708.00    659.00    651.00
    585.00    523.00    511.00    490.00    472.00    500.00    419.00
    452.00    413.00    407.00    350.00    373.00    384.00    323.00
    367.00    340.00    346.00     -1.00     -1.00     -1.00     -1.00
RSHIFT            .90      1.10
RDRIFT          -5.0        5.0
SPECTRUM  SAME   255          1     1     1
FLOW               3     1    1     3   255
BACKGROUNDSAME   255          1     0     0       2.0       800.0
NA 22          1  .95  1.10    1  -2.0   2.0   40  204
CS137          1  .95  1.05    1  -2.0   2.0   40  150
CO 57          1  .95  1.05    1  -2.0   2.0    2  204
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RESULTS FROM FLOW 2
UNCORRECTED LIBRARY
PROBLEM 2

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LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA
FUNCTION LIBRARY  GAMT1    OF   3  ELEMENTS AND  255  CHANNELS,STARTING WITH CHANNEL,   1
SPECTRUM TO BE ANALYZED  GAMMA9  OF 255  CHANNELS,STARTING WITH CHANNEL,   1


FLOW OPTION  2     ITERATIVE MODE
NO GAIN SHIFT OF BACKGROUND
SPECTRUM GAIN SEARCH FROM       0.90 TO       1.10
GAIN SHIFT OF   0.90000   GIVES CHI SQUARE VALUE   0.593949E 03
GAIN SHIFT OF   1.10000   GIVES CHI SQUARE VALUE   0.781919E 03
GAIN SHIFT OF   1.00000   GIVES CHI SQUARE VALUE   0.334998E 03
GAIN SHIFT OF   0.95000   GIVES CHI SQUARE VALUE   0.107330E 03
GAIN SHIFT OF   0.97500   GIVES CHI SQUARE VALUE   0.201325E 03
GAIN SHIFT OF   0.92500   GIVES CHI SQUARE VALUE   0.250909E 03
GAIN SHIFT OF   0.96250   GIVES CHI SQUARE VALUE   0.139128E 03
GAIN SHIFT OF   0.93750   GIVES CHI SQUARE VALUE   0.139166E 03
GAIN SHIFT OF   0.95625   GIVES CHI SQUARE VALUE   0.119038E 03
GAIN SHIFT OF   0.94375   GIVES CHI SQUARE VALUE   0.114913E 03
GAIN SHIFT OF   0.95312   GIVES CHI SQUARE VALUE   0.110563E 03
USING FUNCTIONAL LIBRARY FROM CHANNEL   3   THROUGH  241
AND USING ELEMENTS    NA 22 CS137 CO 57

                        RELATIVE INTENSITY VECTOR

          ELEMENT                              INTENSITY

          NA 22                              0.106822E-00
          CS137                              0.797913E-01
          CO 57                              0.182472E-00
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FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
3	0.849414E 04	0.712831E 04	0.160796E-00
4	0.130147E 05	0.852976E 04	0.344605E-00
5	0.327005E 05	0.260519E 05	0.203317E-00
6	0.398519E 05	0.469306E 05	-0.177623E-00
7	0.132526E 05	0.127487E 05	0.380258E-01
8	0.464787E 04	0.403389E 04	0.132098E-00
9	0.304978E 04	0.263224E 04	0.136908E-00
10	0.291287E 04	0.256210E 04	0.120423E-00
11	0.290982E 04	0.244352E 04	0.160252E-00
12	0.272338E 04	0.229943E 04	0.155668E-00
13	0.254975E 04	0.227896E 04	0.106203E-00
14	0.250282E 04	0.225672E 04	0.983309E-01
15	0.255876E 04	0.220976E 04	0.136392E-00
16	0.245298E 04	0.215687E 04	0.120716E-00
17	0.241437E 04	0.212825E 04	0.118504E-00
18	0.244324E 04	0.211092E 04	0.136015E-00
19	0.244938E 04	0.206086E 04	0.158619E-00
20	0.236417E 04	0.204573E 04	0.134695E-00
21	0.236475E 04	0.201673E 04	0.147171E-00
22	0.228413E 04	0.201710E 04	0.116908E-00
23	0.229209E 04	0.205113E 04	0.105129E-00
24	0.227841E 04	0.208297E 04	0.857810E-01
25	0.227237E 04	0.202743E 04	0.107791E-00
26	0.218590E 04	0.195421E 04	0.105993E-00
27	0.207859E 04	0.174491E 04	0.160531E-00
28	0.187282E 04	0.153742E 04	0.179087E-00
29	0.169993E 04	0.129781E 04	0.236551E-00
30	0.151536E 04	0.114065E 04	0.247272E-00
31	0.139641E 04	0.100947E 04	0.277098E-00
32	0.126344E 04	0.935394E 03	0.259648E-00
33	0.125350E 04	0.885919E 03	0.293242E-00
34	0.114939E 04	0.856676E 03	0.254670E-00
35	0.115331E 04	0.816532E 03	0.292010E-00
36	0.106887E 04	0.806389E 03	0.245565E-00
37	0.108036E 04	0.786837E 03	0.271688E-00
38	0.106729E 04	0.785407E 03	0.264111E-00
39	0.113029E 04	0.760947E 03	0.326767E-00
40	0.112211E 04	0.774421E 03	0.309854E-00
41	0.107721E 04	0.810513E 03	0.247581E-00
42	0.113057E 04	0.880901E 03	0.220835E-00
43	0.120856E 04	0.115210E 04	0.467135E-01
44	0.167799E 04	0.195153E 04	-0.163018E-00
45	0.286611E 04	0.360719E 04	-0.258567E-00
46	0.501324E 04	0.637587E 04	-0.271804E-00
47	0.812571E 04	0.989348E 04	-0.217553E-00
48	0.111956E 05	0.128697E 05	-0.149530E-00
49	0.126996E 05	0.137914E 05	-0.859677E-01
50	0.119911E 05	0.121380E 05	-0.122570E-01
51	0.931136E 04	0.871727E 04	0.638026E-01
52	0.601257E 04	0.524549E 04	0.127579E-00
53	0.335940E 04	0.279803E 04	0.167106E-00
54	0.165879E 04	0.144730E 04	0.127492E-00
55	0.971598E 03	0.809392E 03	0.166948E-00
56	0.601336E 03	0.547230E 03	0.899772E-01
57	0.518187E 03	0.434332E 03	0.161824E-00
58	0.468732E 03	0.376228E 03	0.197349E-00
59	0.512051E 03	0.358343E 03	0.300180E-00
60	0.667563E 03	0.348870E 03	0.477398E-00
61	0.102438E 04	0.358538E 03	0.649995E 00

62	0.171759E 04	0.372113E 03	0.783351E 00
63	0.264798E 04	0.412729E 03	0.844134E 00
64	0.366636E 04	0.516548E 03	0.859111E 00
65	0.445361E 04	0.729005E 03	0.836312E 00
66	0.473915E 04	0.103272E 04	0.782088E 00
67	0.432791E 04	0.140867E 04	0.674515E 00
68	0.339731E 04	0.179393E 04	0.471957E-00
69	0.237763E 04	0.202932E 04	0.146493E-00
70	0.152147E 04	0.204960E 04	-0.347120E-00
71	0.981503E 03	0.179131E 04	-0.825066E 00
72	0.610074E 03	0.139529E 04	-0.128709E 01
73	0.449217E 03	0.100427E 04	-0.123560E 01
74	0.393043E 03	0.684742E 03	-0.742156E 00
75	0.350420E 03	0.526496E 03	-0.502470E 00
76	0.354429E 03	0.428373E 03	-0.208631E-00
77	0.366003E 03	0.381759E 03	-0.430483E-01
78	0.340174E 03	0.353168E 03	-0.381969E-01
79	0.364224E 03	0.350047E 03	0.389246E-01
80	0.335448E 03	0.347901E 03	-0.371209E-01
81	0.320071E 03	0.330931E 03	-0.339303E-01
82	0.314253E 03	0.333392E 03	-0.609024E-01
83	0.311750E 03	0.346211E 03	-0.110541E-00
84	0.317131E 03	0.342579E 03	-0.802429E-01
85	0.318152E 03	0.345890E 03	-0.871864E-01
86	0.319691E 03	0.354009E 03	-0.107347E-00
87	0.318537E 03	0.364050E 03	-0.142881E-00
88	0.333950E 03	0.360952E 03	-0.808583E-01
89	0.364053E 03	0.374626E 03	-0.290408E-01
90	0.368071E 03	0.382637E 03	-0.395752E-01
91	0.358985E 03	0.384774E 03	-0.718377E-01
92	0.384661E 03	0.386269E 03	-0.418008E-02
93	0.367049E 03	0.390649E 03	-0.642951E-01
94	0.377490E 03	0.390649E 03	-0.348597E-01
95	0.416336E 03	0.416927E 03	-0.142044E-02
96	0.395984E 03	0.410625E 03	-0.369732E-01
97	0.424666E 03	0.433378E 03	-0.205152E-01
98	0.421058E 03	0.434980E 03	-0.330640E-01
99	0.424259E 03	0.442030E 03	-0.418891E-01
100	0.408832E 03	0.441390E 03	-0.796348E-01
101	0.409492E 03	0.441176E 03	-0.773731E-01
102	0.401823E 03	0.436583E 03	-0.865048E-01
103	0.393784E 03	0.411586E 03	-0.452077E-01
104	0.368900E 03	0.379646E 03	-0.291298E-01
105	0.312413E 03	0.350591E 03	-0.122203E-00
106	0.272337E 03	0.309144E 03	-0.135152E-00
107	0.233631E 03	0.265987E 03	-0.138491E-00
108	0.184849E 03	0.238000E 03	-0.287539E-00
109	0.189705E 03	0.208410E 03	-0.986033E-01
110	0.164058E 03	0.168352E 03	-0.261736E-01
111	0.135662E 03	0.147201E 03	-0.850604E-01
112	0.102981E 03	0.127439E 03	-0.237494E-00
113	0.899433E 02	0.109493E 03	-0.217354E-00
114	0.898997E 02	0.981696E 02	-0.919908E-01
115	0.834273E 02	0.847100E 02	-0.153753E-01
116	0.824092E 02	0.764847E 02	0.718913E-01
117	0.774464E 02	0.680458E 02	0.121382E-00
118	0.665275E 02	0.646275E 02	0.285597E-01
119	0.630571E 02	0.804372E 02	-0.275625E-00
120	0.861718E 02	0.106395E 03	-0.234684E-00
121	0.135347E 03	0.166215E 03	-0.228068E-00
122	0.198796E 03	0.254771E 03	-0.281571E-00
123	0.314511E 03	0.403040E 03	-0.281484E-00
124	0.527517E 03	0.613267E 03	-0.162553E-00
125	0.774394E 03	0.921556E 03	-0.190035E-00
126	0.102606E 04	0.124651E 04	-0.214853E-00
127	0.142889E 04	0.165735E 04	-0.159881E-00

128	0.167126E 04	0.190891E 04	-0.142201E-00
129	0.188304E 04	0.207833E 04	-0.103712E-00
130	0.196725E 04	0.207182E 04	-0.531564E-01
131	0.184297E 04	0.186501E 04	-0.119599E-01
132	0.161386E 04	0.160853E 04	0.330147E-02
133	0.130328E 04	0.127407E 04	0.224153E-01
134	0.101388E 04	0.970587E 03	0.426960E-01
135	0.681759E 03	0.682808E 03	-0.153807E-02
136	0.458441E 03	0.464570E 03	-0.133685E-01
137	0.298543E 03	0.316942E 03	-0.616274E-01
138	0.199217E 03	0.207128E 03	-0.397143E-01
139	0.135522E 03	0.141112E 03	-0.412464E-01
140	0.953165E 02	0.100306E 03	-0.523481E-01
141	0.560788E 02	0.653752E 02	-0.165774E-00
142	0.426837E 02	0.451858E 02	-0.586186E-01
143	0.375015E 02	0.377083E 02	-0.551289E-02
144	0.348090E 02	0.298034E 02	0.143803E-00
145	0.299707E 02	0.262783E 02	0.123201E-00
146	0.270023E 02	0.216849E 02	0.196925E-00
147	0.287917E 02	0.196553E 02	0.317328E-00
148	0.214828E 02	0.184802E 02	0.139767E-00
149	0.266939E 02	0.204030E 02	0.235667E-00
150	0.201512E 02	0.198689E 02	0.140055E-01
151	0.173522E 02	0.189075E 02	-0.896320E-01
152	0.207131E 02	0.228600E 02	-0.103646E-00
153	0.204499E 02	0.170916E 02	0.164222E-00
154	0.104904E 02	0.196553E 02	-0.873637E 00
155	0.132596E 02	0.186939E 02	-0.409843E-00
156	0.119163E 02	0.199758E 02	-0.676332E 00
157	0.978923E 01	0.188007E 02	-0.920551E 00
158	0.682503E 01	0.170916E 02	-0.150425E 01
159	0.389824E 01	0.184802E 02	-0.374067E 01
160	0.711911E 01	0.139937E 02	-0.965655E 00
161	0.793353E 01	0.139937E 02	-0.763869E 00
162	0.101753E 02	0.120709E 02	-0.186300E-00
163	0.139116E 01	0.110027E 02	-0.690900E 01
164	-0.627087E 00	0.100413E 02	0.170126E 02
165	0.132797E 02	0.107890E 02	0.187551E-00
166	0.908531E 01	0.950718E 01	-0.464341E-01
167	0.976496E 01	0.598205E 01	0.387397E-00
168	0.420297E 01	0.598205E 01	-0.423289E-00
169	0.996101E 01	0.630251E 01	0.367282E-00
170	0.633998E 01	0.416607E 01	0.342889E-00
171	0.717253E 01	0.737073E 01	-0.276338E-01
172	0.447995E 01	0.619569E 01	-0.382981E-00
173	0.470043E 01	0.502065E 01	-0.681250E-01
174	0.843291E 01	0.608887E 01	0.277964E-00
175	0.130991E 02	0.907989E 01	0.306831E-00
176	0.160186E 02	0.114300E 02	0.286455E-00
177	0.120440E 02	0.148483E 02	-0.232835E-00
178	0.190358E 02	0.221122E 02	-0.161612E-00
179	0.287603E 02	0.251032E 02	0.127157E-00
180	0.274305E 02	0.304443E 02	-0.109873E-00
181	0.412722E 02	0.388833E 02	0.578816E-01
182	0.391705E 02	0.373878E 02	0.455106E-01
183	0.336745E 02	0.443312E 02	-0.316462E-00
184	0.349441E 02	0.334354E 02	0.431770E-01
185	0.284768E 02	0.365332E 02	-0.282911E-00
186	0.158879E 02	0.240350E 02	-0.512784E 00
187	0.197784E 02	0.211508E 02	-0.693916E-01
188	0.168581E 02	0.153824E 02	0.875356E-01
189	0.406501E 01	0.126050E 02	-0.210086E 01
190	0.425448E 01	0.801167E 01	-0.883114E 00
191	0.364529E 01	0.587522E 01	-0.611731E 00
192	0.460493E 01	0.491382E 01	-0.670798E-01
193	0.187121E 01	0.341831E 01	-0.826790E 00

194	0.698805E 00	0.202962E 01	-0.190442E 01
195	-0.136724E-00	0.117504E 01	0.959426E 01
196	0.263366E-00	-0.	0.100000E 01
197	-0.123482E-01	-0.	0.100000E 01
198	0.362207E-00	-0.	0.100000E 01
199	-0.802007E-01	-0.	0.100000E 01
200	-0.954389E 00	-0.	0.100000E 01
201	0.282613E 01	-0.	0.100000E 01
202	0.129880E 01	-0.	0.100000E 01
203	0.135488E 01	-0.	0.100000E 01
204	0.165152E-00	-0.	0.100000E 01
205	-0.131678E 01	-0.	0.100000E 01
206	0.311049E-00	-0.	0.100000E 01
207	-0.285632E-00	-0.	0.100000E 01
208	0.125588E 01	-0.	0.100000E 01
209	0.226282E 01	-0.	0.100000E 01
210	0.854164E 00	-0.	0.100000E 01
211	-0.370634E-00	-0.	0.100000E 01
212	0.815088E 00	-0.	0.100000E 01
213	0.118417E 01	-0.	0.100000E 01
214	0.132248E 01	-0.	0.100000E 01
215	0.944524E 00	-0.	0.100000E 01
216	-0.294664E-00	-0.	0.100000E 01
217	0.116330E 01	-0.	0.100000E 01
218	-0.240479E-00	-0.	0.100000E 01
219	0.222295E 01	-0.	0.100000E 01
220	0.382102E-00	-0.	0.100000E 01
221	0.226741E 01	-0.	0.100000E 01
222	-0.185658E 01	-0.	0.100000E 01
223	-0.190486E-01	-0.	0.100000E 01
224	-0.803034E 00	-0.	0.100000E 01
225	0.191232E-00	-0.	0.100000E 01
226	-0.503258E 00	-0.	0.100000E 01
227	-0.943806E 00	-0.	0.100000E 01
228	0.384323E-00	-0.	0.100000E 01
229	-0.156984E 01	-0.	0.100000E 01
230	-0.525412E 00	-0.	0.100000E 01
231	-0.127106E-00	-0.	0.100000E 01
232	-0.100313E 01	-0.	0.100000E 01
233	-0.693134E 00	-0.	0.100000E 01
234	-0.123204E-01	-0.	0.100000E 01
235	0.318732E-00	-0.	0.100000E 01
236	0.121419E 01	-0.	0.100000E 01
237	-0.128274E 01	-0.	0.100000E 01
238	-0.162750E 01	-0.	0.100000E 01
239	0.632341E 00	-0.	0.100000E 01
240	-0.130750E 01	-0.	0.100000E 01
241	-0.106210E 01	-0.	0.100000E 01

GAIN SHIFT OF 0.94844 GIVES CHI SQUARE VALUE 0.107895E 03

SPECTRUM ZERO SEARCH FROM -5.00 TO 5.00

ZERO DRIFT OF -5.00000 GIVES CHI SQUARE VALUE 0.609500E 03

ZERO DRIFT OF 5.00000 GIVES CHI SQUARE VALUE 0.891640E 03

ZERO DRIFT OF 0. GIVES CHI SQUARE VALUE 0.107895E 03

ZERO DRIFT OF -2.50000 GIVES CHI SQUARE VALUE 0.550730E 03

ZERO DRIFT OF 2.50000 GIVES CHI SQUARE VALUE 0.589563E 03

ZERO DRIFT OF -1.25000 GIVES CHI SQUARE VALUE 0.380376E 03

ZERO DRIFT OF 1.25000 GIVES CHI SQUARE VALUE 0.337306E 03

ZERO DRIFT OF -0.62500 GIVES CHI SQUARE VALUE 0.222135E 03

ZERO DRIFT OF 0.62500 GIVES CHI SQUARE VALUE 0.185303E 03

ZERO DRIFT OF -0.31250 GIVES CHI SQUARE VALUE 0.150392E 03

ZERO DRIFT OF 0.31250 GIVES CHI SQUARE VALUE 0.130118E 03

ZERO DRIFT OF -0.15625 GIVES CHI SQUARE VALUE 0.125263E 03

ZERO DRIFT OF 0.15625 GIVES CHI SQUARE VALUE 0.113677E 03

ZERO DRIFT OF -0.07813 GIVES CHI SQUARE VALUE 0.115696E 03

ZERO DRIFT OF 0.07813 GIVES CHI SQUARE VALUE 0.109163E 03

ZERO DRIFT OF -0.03906 GIVES CHI SQUARE VALUE 0.111732E 03

ZERO DRIFT OF 0.03906 GIVES CHI SQUARE VALUE 0.108071E 03

ZERO DRIFT OF -0.01953 GIVES CHI SQUARE VALUE 0.109966E 03

ZERO DRIFT OF 0.01953 GIVES CHI SQUARE VALUE 0.107861E 03

ZERO DRIFT OF 0.00977 GIVES CHI SQUARE VALUE 0.107846E 03

ZERO DRIFT OF 0.01465 GIVES CHI SQUARE VALUE 0.107846E 03

USING FUNCTIONAL LIBRARY FROM CHANNEL 3 THROUGH 241

AND USING ELEMENTS NA 22 CS137 CO 57

RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
NA 22	0.106769E-00
CS137	0.804968E-01
CO 57	0.182376E-00

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
3	0.843414E 04	0.712732E 04	0.154944E-00
4	0.129484E 05	0.852799E 04	0.341387E-00
5	0.324127E 05	0.260410E 05	0.196581E-00
6	0.397477E 05	0.469087E 05	-0.180164E-00
7	0.136431E 05	0.127444E 05	0.658714E-01
8	0.477469E 04	0.403418E 04	0.155091E-00
9	0.307388E 04	0.263322E 04	0.143358E-00
10	0.291540E 04	0.256307E 04	0.120851E-00
11	0.291029E 04	0.244472E 04	0.159972E-00
12	0.272641E 04	0.230085E 04	0.156088E-00
13	0.255262E 04	0.228049E 04	0.106610E-00
14	0.250384E 04	0.225813E 04	0.981330E-01
15	0.255822E 04	0.221102E 04	0.135718E-00
16	0.245471E 04	0.215802E 04	0.120867E-00
17	0.241501E 04	0.212938E 04	0.118270E-00
18	0.244283E 04	0.211212E 04	0.135381E-00
19	0.244941E 04	0.206199E 04	0.158165E-00
20	0.236570E 04	0.204685E 04	0.134778E-00
21	0.236503E 04	0.201780E 04	0.146820E-00
22	0.228554E 04	0.201817E 04	0.116983E-00
23	0.229209E 04	0.205223E 04	0.104644E-00
24	0.227865E 04	0.208405E 04	0.854011E-01
25	0.227247E 04	0.202839E 04	0.107409E-00
26	0.218725E 04	0.195519E 04	0.106096E-00
27	0.208029E 04	0.174595E 04	0.160721E-00
28	0.187599E 04	0.153859E 04	0.179851E-00
29	0.170256E 04	0.129900E 04	0.237031E-00
30	0.151807E 04	0.114197E 04	0.247747E-00
31	0.139809E 04	0.101075E 04	0.277051E-00
32	0.126531E 04	0.936693E 03	0.259715E-00
33	0.125370E 04	0.887219E 03	0.292317E-00
34	0.115105E 04	0.857990E 03	0.254601E-00
35	0.115344E 04	0.817880E 03	0.290923E-00
36	0.107027E 04	0.807851E 03	0.245186E-00
37	0.108032E 04	0.788317E 03	0.270290E-00
38	0.106753E 04	0.786983E 03	0.262803E-00
39	0.112942E 04	0.762468E 03	0.324901E-00
40	0.112227E 04	0.775964E 03	0.308575E-00
41	0.107789E 04	0.812071E 03	0.246612E-00
42	0.112982E 04	0.882442E 03	0.218950E-00
43	0.120744E 04	0.115343E 04	0.447293E-01
44	0.167112E 04	0.195235E 04	-0.168290E-00
45	0.284872E 04	0.360696E 04	-0.266168E-00
46	0.498180E 04	0.637401E 04	-0.279458E-00
47	0.808014E 04	0.988961E 04	-0.223941E-00
48	0.111506E 05	0.128642E 05	-0.153671E-00
49	0.126776E 05	0.137852E 05	-0.873684E-01
50	0.120014E 05	0.121326E 05	-0.109268E-01
51	0.935059E 04	0.871341E 04	0.681434E-01
52	0.606090E 04	0.524330E 04	0.134897E-00
53	0.339830E 04	0.279700E 04	0.176942E-00
54	0.168372E 04	0.144690E 04	0.140652E-00
55	0.981711E 03	0.809297E 03	0.175626E-00
56	0.606774E 03	0.547251E 03	0.980983E-01
57	0.519422E 03	0.434379E 03	0.163727E-00
58	0.469443E 03	0.376286E 03	0.198441E-00
59	0.511382E 03	0.358453E 03	0.299050E-00
60	0.665237E 03	0.348968E 03	0.475423E-00
61	0.101910E 04	0.358691E 03	0.648030E 00

62	0.170737E 04	0.372545E 03	0.781801E 00
63	0.263434E 04	0.413515E 03	0.843029E 00
64	0.365144E 04	0.518289E 03	0.858059E 00
65	0.444213E 04	0.732565E 03	0.835087E 00
66	0.473505E 04	0.103896E 04	0.780581E 00
67	0.433402E 04	0.141823E 04	0.672767E 00
68	0.341099E 04	0.180690E 04	0.470270E-00
69	0.239261E 04	0.204436E 04	0.145554E-00
70	0.153403E 04	0.206485E 04	-0.346024E-00
71	0.989442E 03	0.180417E 04	-0.823418E 00
72	0.615529E 03	0.140467E 04	-0.128206E 01
73	0.451600E 03	0.101011E 04	-0.123675E 01
74	0.393878E 03	0.687801E 03	-0.746227E 00
75	0.351053E 03	0.528079E 03	-0.504273E 00
76	0.354372E 03	0.429041E 03	-0.210709E-00
77	0.365842E 03	0.381930E 03	-0.439735E-01
78	0.340550E 03	0.353145E 03	-0.369865E-01
79	0.363871E 03	0.349956E 03	0.382406E-01
80	0.335877E 03	0.347773E 03	-0.354161E-01
81	0.320290E 03	0.330776E 03	-0.327403E-01
82	0.314334E 03	0.333227E 03	-0.601048E-01
83	0.311788E 03	0.346039E 03	-0.109855E-00
84	0.317065E 03	0.342409E 03	-0.799343E-01
85	0.318149E 03	0.345719E 03	-0.866576E-01
86	0.319675E 03	0.353834E 03	-0.106854E-00
87	0.318566E 03	0.363870E 03	-0.142211E-00
88	0.333732E 03	0.360774E 03	-0.810271E-01
89	0.363614E 03	0.374440E 03	-0.297724E-01
90	0.368012E 03	0.382448E 03	-0.392253E-01
91	0.359133E 03	0.384583E 03	-0.708652E-01
92	0.384284E 03	0.386078E 03	-0.466860E-02
93	0.367307E 03	0.390455E 03	-0.630211E-01
94	0.377335E 03	0.390455E 03	-0.347710E-01
95	0.415760E 03	0.416721E 03	-0.230986E-02
96	0.396278E 03	0.410421E 03	-0.356911E-01
97	0.424250E 03	0.433163E 03	-0.210084E-01
98	0.421103E 03	0.434765E 03	-0.324427E-01
99	0.424216E 03	0.441811E 03	-0.414768E-01
100	0.409052E 03	0.441171E 03	-0.785196E-01
101	0.409484E 03	0.440957E 03	-0.768598E-01
102	0.401937E 03	0.436366E 03	-0.856585E-01
103	0.393917E 03	0.411382E 03	-0.443384E-01
104	0.369269E 03	0.379458E 03	-0.275926E-01
105	0.313246E 03	0.350417E 03	-0.118664E-00
106	0.272929E 03	0.308990E 03	-0.132126E-00
107	0.234210E 03	0.265856E 03	-0.135117E-00
108	0.185575E 03	0.237882E 03	-0.281863E-00
109	0.189639E 03	0.208307E 03	-0.984411E-01
110	0.164439E 03	0.168268E 03	-0.232885E-01
111	0.136088E 03	0.147128E 03	-0.811273E-01
112	0.103463E 03	0.127376E 03	-0.231125E-00
113	0.901358E 02	0.109439E 03	-0.214152E-00
114	0.898977E 02	0.981210E 02	-0.914744E-01
115	0.835264E 02	0.846681E 02	-0.136677E-01
116	0.824140E 02	0.764468E 02	0.724044E-01
117	0.775128E 02	0.680121E 02	0.122570E-00
118	0.666775E 02	0.645954E 02	0.312256E-01
119	0.631003E 02	0.803973E 02	-0.274119E-00
120	0.858235E 02	0.106342E 03	-0.239081E-00
121	0.134623E 03	0.166133E 03	-0.234065E-00
122	0.197871E 03	0.254645E 03	-0.286924E-00
123	0.312822E 03	0.402841E 03	-0.287764E-00
124	0.524400E 03	0.612963E 03	-0.168883E-00
125	0.770790E 03	0.921099E 03	-0.195006E-00
126	0.102238E 04	0.124589E 04	-0.218623E-00
127	0.142300E 04	0.165653E 04	-0.164105E-00

128	0.166772E 04	0.190797E 04	-0.144060E-00
129	0.187994E 04	0.207730E 04	-0.104982E-00
130	0.196601E 04	0.207079E 04	-0.532957E-01
131	0.184479E 04	0.186409E 04	-0.104579E-01
132	0.161722E 04	0.160773E 04	0.586399E-02
133	0.130783E 04	0.127344E 04	0.262979E-01
134	0.101812E 04	0.970106E 03	0.471569E-01
135	0.686626E 03	0.682469E 03	0.605322E-02
136	0.461714E 03	0.464340E 03	-0.568624E-02
137	0.300892E 03	0.316785E 03	-0.528189E-01
138	0.200675E 03	0.207026E 03	-0.316484E-01
139	0.136463E 03	0.141042E 03	-0.335606E-01
140	0.959088E 02	0.100256E 03	-0.453299E-01
141	0.566545E 02	0.653428E 02	-0.153355E-00
142	0.428812E 02	0.451634E 02	-0.532208E-01
143	0.375756E 02	0.376896E 02	-0.303425E-02
144	0.348497E 02	0.297886E 02	0.145226E-00
145	0.300415E 02	0.262653E 02	0.125702E-00
146	0.270403E 02	0.216742E 02	0.198450E-00
147	0.287630E 02	0.196456E 02	0.316985E-00
148	0.215864E 02	0.184711E 02	0.144319E-00
149	0.266149E 02	0.203929E 02	0.233776E-00
150	0.202417E 02	0.198591E 02	0.189017E-01
151	0.173817E 02	0.188982E 02	-0.872459E-01
152	0.206561E 02	0.228486E 02	-0.106143E-00
153	0.204519E 02	0.170831E 02	0.164721E-00
154	0.106169E 02	0.196456E 02	-0.850411E 00
155	0.132068E 02	0.186846E 02	-0.414770E-00
156	0.119347E 02	0.199659E 02	-0.672930E 00
157	0.981926E 01	0.187914E 02	-0.913730E 00
158	0.686783E 01	0.170831E 02	-0.148741E 01
159	0.394803E 01	0.184711E 02	-0.367855E 01
160	0.708654E 01	0.139868E 02	-0.973710E 00
161	0.793585E 01	0.139868E 02	-0.762480E 00
162	0.101541E 02	0.120649E 02	-0.188178E-00
163	0.153159E 01	0.109972E 02	-0.618028E 01
164	-0.589430E 00	0.100363E 02	0.180272E 02
165	0.130861E 02	0.107837E 02	0.175944E-00
166	0.915620E 01	0.950247E 01	-0.378179E-01
167	0.975845E 01	0.597908E 01	0.387292E-00
168	0.428811E 01	0.597908E 01	-0.394340E-00
169	0.988183E 01	0.629939E 01	0.362528E-00
170	0.639522E 01	0.416400E 01	0.348888E-00
171	0.716286E 01	0.736708E 01	-0.285111E-01
172	0.452339E 01	0.619262E 01	-0.369023E-00
173	0.469544E 01	0.501816E 01	-0.687298E-01
174	0.838197E 01	0.608585E 01	0.273936E-00
175	0.130348E 02	0.907539E 01	0.303755E-00
176	0.159735E 02	0.114243E 02	0.284798E-00
177	0.121017E 02	0.148409E 02	-0.226348E-00
178	0.189348E 02	0.221012E 02	-0.167229E-00
179	0.286164E 02	0.250908E 02	0.123202E-00
180	0.274500E 02	0.304293E 02	-0.108534E-00
181	0.410648E 02	0.388640E 02	0.535932E-01
182	0.391976E 02	0.373693E 02	0.466438E-01
183	0.337559E 02	0.443093E 02	-0.312636E-00
184	0.349175E 02	0.334188E 02	0.429200E-01
185	0.285654E 02	0.365151E 02	-0.278300E-00
186	0.160702E 02	0.240231E 02	-0.494884E-00
187	0.197209E 02	0.211403E 02	-0.719742E-01
188	0.168998E 02	0.153748E 02	0.902369E-01
189	0.425332E 01	0.125988E 02	-0.196210E 01
190	0.425346E 01	0.800770E 01	-0.882631E 00
191	0.366007E 01	0.587231E 01	-0.604426E 00
192	0.459541E 01	0.491139E 01	-0.687596E-01
193	0.191686E 01	0.341662E 01	-0.782403E 00

194	0.720483E 00	0.202862E 01	-0.181563E 01
195	-0.120567E-00	0.117446E 01	0.107412E 02
196	0.257615E-00	-0.	0.100000E 01
197	-0.636852E-02	-0.	0.100000E 01
198	0.359357E-00	-0.	0.100000E 01
199	-0.711932E-01	-0.	0.100000E 01
200	-0.938104E 00	-0.	0.100000E 01
201	0.277078E 01	-0.	0.100000E 01
202	0.132466E 01	-0.	0.100000E 01
203	0.135600E 01	-0.	0.100000E 01
204	0.182836E-00	-0.	0.100000E 01
205	-0.129317E 01	-0.	0.100000E 01
206	0.287717E-00	-0.	0.100000E 01
207	-0.277185E-00	-0.	0.100000E 01
208	0.123484E 01	-0.	0.100000E 01
209	0.224704E 01	-0.	0.100000E 01
210	0.876886E 00	-0.	0.100000E 01
211	-0.352620E-00	-0.	0.100000E 01
212	0.798854E 00	-0.	0.100000E 01
213	0.117847E 01	-0.	0.100000E 01
214	0.131918E 01	-0.	0.100000E 01
215	0.949511E 00	-0.	0.100000E 01
216	-0.278380E-00	-0.	0.100000E 01
217	0.114264E 01	-0.	0.100000E 01
218	-0.220428E-00	-0.	0.100000E 01
219	0.218554E 01	-0.	0.100000E 01
220	0.407420E-00	-0.	0.100000E 01
221	0.223866E 01	-0.	0.100000E 01
222	-0.179786E 01	-0.	0.100000E 01
223	-0.458924E-01	-0.	0.100000E 01
224	-0.792246E 00	-0.	0.100000E 01
225	0.178535E-00	-0.	0.100000E 01
226	-0.494403E-00	-0.	0.100000E 01
227	-0.937572E 00	-0.	0.100000E 01
228	0.366004E-00	-0.	0.100000E 01
229	-0.154422E 01	-0.	0.100000E 01
230	-0.540272E 00	-0.	0.100000E 01
231	-0.132830E-00	-0.	0.100000E 01
232	-0.989496E 00	-0.	0.100000E 01
233	-0.693134E 00	-0.	0.100000E 01
234	-0.234652E-01	-0.	0.100000E 01
235	0.314431E-00	-0.	0.100000E 01
236	0.120137E 01	-0.	0.100000E 01
237	-0.124437E 01	-0.	0.100000E 01
238	-0.162216E 01	-0.	0.100000E 01
239	0.601655E 00	-0.	0.100000E 01
240	-0.127681E 01	-0.	0.100000E 01
241	-0.106526E 01	-0.	0.100000E 01

ZERO DRIFT OF 0.01465 GIVES CHI SQUARE VALUE 0.107846E 03

CORRELATION MATRIX STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
OFF DIAGONAL ELEMENT = CROSS CORRELATION

ROW 1

0.41329E-02

ROW 2

0.51057E-01 0.11820E-01

ROW 3

0.49181E-02 0.36297E-03 0.96670E-02

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RESULTS FROM FLOW 3

LIBRARY PREPARATION SUBROUTINE

PROBLEM 2

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LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA
FUNCTION LIBRARY  GAMT1    OF   3  ELEMENTS AND  255  CHANNELS, STARTING WITH CHANNEL,   1
SPECTRUM TO BE ANALYZED  GAMMA9  OF 255  CHANNELS, STARTING WITH CHANNEL,   1


FLOW OPTION  3     ITERATIVE MODE
LIBRARY   GAMT1  255    3    1
COMPONENT BEING STORED,  NA 22
GAIN SEARCH FROM    0.95000 TO    1.10000
GAIN SHIFT OF   0.95000   GIVES CHI SQUARE VALUE   0.784098E 03
GAIN SHIFT OF   1.10000   GIVES CHI SQUARE VALUE   0.486003E 03
GAIN SHIFT OF   1.02500   GIVES CHI SQUARE VALUE   0.400638E 03
GAIN SHIFT OF   0.98750   GIVES CHI SQUARE VALUE   0.700764E 03
GAIN SHIFT OF   1.06250   GIVES CHI SQUARE VALUE   0.166590E 03
GAIN SHIFT OF   1.04375   GIVES CHI SQUARE VALUE   0.220298E 03
GAIN SHIFT OF   1.08125   GIVES CHI SQUARE VALUE   0.286856E 03
GAIN SHIFT OF   1.05312   GIVES CHI SQUARE VALUE   0.171706E 03
GAIN SHIFT OF   1.07187   GIVES CHI SQUARE VALUE   0.208426E 03
GAIN SHIFT OF   1.05781   GIVES CHI SQUARE VALUE   0.163005E 03
USING FUNCTIONAL LIBRARY FROM CHANNEL  40   THROUGH  204
AND USING ELEMENTS    NA 22

                    RELATIVE INTENSITY VECTOR

          ELEMENT                          INTENSITY

          NA 22                          0.1055018+00
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FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE (P.C.) ACTUAL-CALCULATED
40	0.101155E 04	0.938796E 03	0.467359E+00
41	0.107328E 04	0.924582E 03	0.511234E 00
42	0.107811E 04	0.927532E 03	0.510690E 00
43	0.100661E 04	0.950160E 03	0.453454E+00
44	0.107709E 04	0.998865E 03	0.444000E+00
45	0.106019E 04	0.765898E 03	0.277584E+00
46	0.131374E 04	0.125396E 04	0.455064E+01
47	0.202212E 04	0.231999E 04	-0.147308E+00
48	0.358105E 04	0.419553E 04	-0.171593E+00
49	0.592343E 04	0.688916E 04	-0.163035E+00
50	0.913197E 04	0.988161E 04	-0.820888E+01
51	0.115659E 05	0.121170E 05	-0.476454E+01
52	0.122823E 05	0.125671E 05	-0.231839E+01
53	0.110143E 05	0.109484E 05	0.599003E+02
54	0.819101E 04	0.793476E 04	0.312844E+01
55	0.518719E 04	0.487590E 04	0.600122E+01
56	0.292116E 04	0.271492E 04	0.706006E+01
57	0.148432E 04	0.146453E 04	0.133331E+01
58	0.915410E 03	0.826078E 03	0.975873E+01
59	0.576025E 03	0.536356E 03	0.590651E+01
60	0.488760E 03	0.407886E 03	0.165467E+00
61	0.430165E 03	0.344344E 03	0.199508E+00
62	0.448635E 03	0.314023E 03	0.300048E+00
63	0.562507E 03	0.301832E 03	0.463416E+00
64	0.789687E 03	0.300109E 03	0.619965E 00
65	0.134392E 04	0.294501E 03	0.780864E 00
66	0.211844E 04	0.285975E 03	0.865007E 00
67	0.306372E 04	0.285057E 03	0.906957E 00
68	0.395419E 04	0.284274E 03	0.928108E 00
69	0.448533E 04	0.288724E 03	0.935629E 00
70	0.452007E 04	0.289118E 03	0.936037E 00
71	0.388613E 04	0.289399E 03	0.925530E 00
72	0.294213E 04	0.288589E 03	0.901912E 00
73	0.203397E 04	0.290794E 03	0.857032E 00
74	0.130581E 04	0.287777E 03	0.779618E 00
75	0.873365E 03	0.296891E 03	0.660061E 00
76	0.553482E 03	0.296135E 03	0.464960E+00
77	0.423077E 03	0.301973E 03	0.286248E+00
78	0.373890E 03	0.300652E 03	0.195880E+00
79	0.331815E 03	0.304776E 03	0.814880E+01
80	0.333325E 03	0.310189E 03	0.694111E+01
81	0.353877E 03	0.316829E 03	0.104693E+00
82	0.311563E 03	0.317349E 03	-0.185610E+01
83	0.352657E 03	0.316360E 03	0.102924E+00
84	0.325495E 03	0.319288E 03	0.190709E+01
85	0.303317E 03	0.315995E 03	-0.418105E+01
86	0.305745E 03	0.309038E 03	-0.101698E+01
87	0.292557E 03	0.314207E 03	-0.740007E+01
88	0.303115E 03	0.322594E 03	-0.642640E+01
89	0.302255E 03	0.320270E 03	-0.596010E+01
90	0.303277E 03	0.323557E 03	-0.668682E+01
91	0.305292E 03	0.330770E 03	-0.834542E+01
92	0.302195E 03	0.339633E 03	-0.123887E+00
93	0.321182E 03	0.337243E 03	-0.500048E+01
94	0.350060E 03	0.348016E 03	0.583804E+02
95	0.348615E 03	0.355814E 03	-0.206496E+01
96	0.338315E 03	0.358753E 03	-0.604104E+01
97	0.363635E 03	0.360220E 03	0.939033E+02
98	0.346072E 03	0.363275E 03	-0.497065E+01

99	0.351382E 03	0.364730E 03	+0.3758638+01
100	0.398972E 03	0.377849E 03	0.5294408+01
101	0.366097E 03	0.386440E 03	+0.5556618+01
102	0.405210E 03	0.392418E 03	0.3156948+01
103	0.393217E 03	0.405179E 03	+0.3041908+01
104	0.413510E 03	0.408201E 03	0.1283918+01
105	0.385892E 03	0.412546E 03	+0.6907038+01
106	0.393285E 03	0.412063E 03	+0.4774658+01
107	0.387072E 03	0.411252E 03	+0.6246848+01
108	0.380885E 03	0.405341E 03	+0.6420828+01
109	0.372235E 03	0.383001E 03	+0.2892208+01
110	0.341600E 03	0.354810E 03	+0.3867058+01
111	0.281290E 03	0.329133E 03	+0.1700838+00
112	0.254477E 03	0.293320E 03	+0.1526358+00
113	0.216585E 03	0.255422E 03	+0.1793168+00
114	0.170402E 03	0.228230E 03	+0.3393608+00
115	0.181697E 03	0.202458E 03	+0.1142618+00
116	0.155002E 03	0.169888E 03	+0.9603558+01
117	0.128575E 03	0.145223E 03	+0.1294788+00
118	0.968975E 02	0.127269E 03	+0.3134378+00
119	0.823800E 02	0.110668E 03	+0.3433818+00
120	0.837150E 02	0.975590E 02	+0.1653718+00
121	0.754375E 02	0.867930E 02	+0.1505288+00
122	0.757425E 02	0.765374E 02	+0.1049468+01
123	0.751750E 02	0.692221E 02	0.7918698+01
124	0.654150E 02	0.628192E 02	0.3968178+01
125	0.583150E 02	0.628252E 02	+0.7734138+01
126	0.627025E 02	0.778569E 02	+0.2416878+00
127	0.102467E 03	0.102636E 03	+0.1644098+02
128	0.151947E 03	0.155554E 03	+0.2373498+01
129	0.214392E 03	0.233719E 03	+0.9012878+01
130	0.340302E 03	0.361782E 03	+0.6311868+01
131	0.559600E 03	0.541266E 03	0.3276228+01
132	0.781742E 03	0.798765E 03	+0.2177458+01
133	0.100867E 04	0.108224E 04	+0.7293678+01
134	0.139285E 04	0.142330E 04	+0.2186268+01
135	0.159396E 04	0.169345E 04	+0.6241468+01
136	0.178508E 04	0.187198E 04	+0.4868108+01
137	0.187352E 04	0.193732E 04	+0.3405618+01
138	0.177173E 04	0.184594E 04	+0.4188638+01
139	0.158321E 04	0.164471E 04	+0.3883938+01
140	0.129145E 04	0.139295E 04	+0.7859358+01
141	0.105752E 04	0.110625E 04	+0.4608018+01
142	0.725605E 03	0.841896E 03	+0.1602678+00
143	0.496477E 03	0.599883E 03	+0.2082788+00
144	0.342562E 03	0.415830E 03	+0.2138818+00
145	0.211560E 03	0.288189E 03	+0.3622108+00
146	0.167185E 03	0.192111E 03	+0.1490928+00
147	0.970150E 02	0.133843E 03	+0.3796168+00
148	0.847775E 02	0.970274E 02	+0.1444958+00
149	0.355900E 02	0.657104E 02	+0.8463168 00
150	0.402275E 02	0.459188E 02	+0.1414778+00
151	0.314400E 02	0.369698E 02	+0.1758838+00
152	0.299100E 02	0.300935E 02	+0.6135548+02
153	0.247875E 02	0.257258E 02	+0.3785468+01
154	0.214575E 02	0.220325E 02	+0.2679908+01
155	0.226275E 02	0.192441E 02	0.1495268+00
156	0.155350E 02	0.173810E 02	+0.1477978+00
157	0.214575E 02	0.180072E 02	0.1607968+00
158	0.154150E 02	0.188674E 02	+0.2239648+00
159	0.128875E 02	0.182722E 02	+0.4178278+00
160	0.168850E 02	0.185961E 02	+0.1013368+00
161	0.228575E 02	0.202613E 02	0.1135818+00
162	0.116575E 02	0.163076E 02	+0.3588948+00
163	0.124600E 02	0.182690E 02	+0.4662128+00
164	0.210125E 02	0.174978E 02	0.1672678+00

165	0.970750E 01	0.186292E 02	-0.919052E 00
166	0.183525E 02	0.176327E 02	0.392193E+01
167	0.758750E 01	0.161603E 02	-0.112985E 01
168	0.983750E 01	0.170186E 02	-0.729968E 00
169	0.121900E 02	0.140552E 02	-0.153013E+00
170	0.113400E 02	0.130653E 02	-0.152139E+00
171	0.135125E 02	0.118905E 02	0.120035E+00
172	0.278500E 01	0.106719E 02	-0.283193E 01
173	0.166500E 01	0.978344E 01	-0.487594E 01
174	0.149200E 02	0.971744E 01	0.348697E+00
175	0.101950E 02	0.955170E 01	0.630992E+01
176	0.110400E 02	0.762211E 01	0.309591E+00
177	0.400500E 01	0.558515E 01	-0.394544E+00
178	0.111025E 02	0.566647E 01	0.489622E+00
179	0.600250E 01	0.545123E 01	0.918399E+01
180	0.800500E 01	0.437582E 01	0.453364E+00
181	0.469000E 01	0.676340E 01	-0.442095E+00
182	0.244000E 01	0.572628E 01	-0.134683E 01
183	0.650250E 01	0.468915E 01	0.278869E+00
184	0.795000E 01	0.562891E 01	0.291961E+00
185	0.135275E 02	0.816810E 01	0.396185E+00
186	0.133825E 02	0.103086E 02	0.225693E+00
187	0.735250E 01	0.131607E 02	-0.785966E 00
188	0.202775E 02	0.187818E 02	0.737596E+01
189	0.273400E 02	0.225178E 02	0.176378E+00
190	0.234600E 02	0.265093E 02	-0.129975E+00
191	0.408600E 02	0.328470E 02	0.196110E+00
192	0.361700E 02	0.355960E 02	0.158684E+01
193	0.315525E 02	0.378374E 02	-0.199188E+00
194	0.338600E 02	0.373478E 02	-0.103006E+00
195	0.291275E 02	0.322082E 02	-0.105765E+00
196	0.161350E 02	0.307482E 02	-0.905682E 00
197	0.202675E 02	0.218119E 02	-0.761988E+01
198	0.214475E 02	0.187849E 02	0.124145E+00
199	0.562000E 01	0.140401E 02	-0.149023E 01
200	0.685750E 01	0.114710E 02	-0.672761E 00
201	0.486000E 01	0.745064E 01	-0.533053E 00
202	0.609750E 01	0.556496E 01	0.873375E+01
203	0.623000E 01	0.467265E 01	0.249975E+00
204	0.247500E-00	0.339982E 01	-0.127366E 02

GAIN SHIFT OF 1.05781 GIVES CHI SQUARE VALUE 0.163005E 03

ZERO SEARCH FROM -2.00000 TO 2.00000

ZERO DRIFT OF -2.00000 GIVES CHI SQUARE VALUE 0.392638E 03

ZERO DRIFT OF 2.00000 GIVES CHI SQUARE VALUE 0.359685E 03

ZERO DRIFT OF 0. GIVES CHI SQUARE VALUE 0.163005E 03

ZERO DRIFT OF -1.00000 GIVES CHI SQUARE VALUE 0.242159E 03

ZERO DRIFT OF 1.00000 GIVES CHI SQUARE VALUE 0.212768E 03

ZERO DRIFT OF -0.50000 GIVES CHI SQUARE VALUE 0.188103E 03

ZERO DRIFT OF 0.50000 GIVES CHI SQUARE VALUE 0.171800E 03

ZERO DRIFT OF -0.25000 GIVES CHI SQUARE VALUE 0.171330E 03

ZERO DRIFT OF 0.25000 GIVES CHI SQUARE VALUE 0.162977E 03

ZERO DRIFT OF 0.12500 GIVES CHI SQUARE VALUE 0.161866E 03

ZERO DRIFT OF 0.18750 GIVES CHI SQUARE VALUE 0.162141E 03

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ZERO DRIFT OF   0.06250   GIVES CHI SQUARE VALUE   0.1621558 03
ZERO DRIFT OF   0.15625   GIVES CHI SQUARE VALUE   0.1619338 03
ZERO DRIFT OF   0.09375   GIVES CHI SQUARE VALUE   0.1619408 03
ZERO DRIFT OF   0.14063   GIVES CHI SQUARE VALUE   0.1618828 03
ZERO DRIFT OF   0.10938   GIVES CHI SQUARE VALUE   0.1618868 03
ZERO DRIFT OF   0.13281   GIVES CHI SQUARE VALUE   0.1618708 03
ZERO DRIFT OF   0.11719   GIVES CHI SQUARE VALUE   0.1618728 03
ZERO DRIFT OF   0.12891   GIVES CHI SQUARE VALUE   0.1618678 03
ZERO DRIFT OF   0.12109   GIVES CHI SQUARE VALUE   0.1618688 03
USING FUNCTIONAL LIBRARY FROM CHANNEL  40   THROUGH  204
AND USING ELEMENTS    NA 22

                    RELATIVE INTENSITY VECTOR

          ELEMENT                          INTENSITY
          NA 22                          0.1056228+00
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FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE (P.C.) ACTUAL-CALCULATED
40	0.101155E 04	0.540840E 03	0.465338E+00
41	0.107328E 04	0.526966E 03	0.5090138 00
42	0.107811E 04	0.527771E 03	0.5104688 00
43	0.100661E 04	0.547963E 03	0.4556378+00
44	0.107709E 04	0.593460E 03	0.4490188+00
45	0.106019E 04	0.745878E 03	0.2964678+00
46	0.131374E 04	0.119433E 04	0.9089698+01
47	0.202212E 04	0.218926E 04	+0.8269698+01
48	0.358105E 04	0.396566E 04	+0.1074028+00
49	0.592343E 04	0.656001E 04	+0.1074688+00
50	0.913197E 04	0.951852E 04	+0.4232868+01
51	0.115659E 05	0.118512E 05	+0.2466708+01
52	0.122823E 05	0.125253E 05	+0.1977808+01
53	0.110143E 05	0.111636E 05	+0.1354858+01
54	0.819101E 04	0.832105E 04	+0.1587578+01
55	0.518719E 04	0.526432E 04	+0.1486898+01
56	0.292116E 04	0.298849E 04	+0.2304928+01
57	0.148432E 04	0.162270E 04	+0.9322638+01
58	0.915410E 03	0.906929E 03	0.9264288+02
59	0.570025E 03	0.573232E 03	+0.5626168+02
60	0.488760E 03	0.424434E 03	0.1316108+00
61	0.430165E 03	0.352693E 03	0.1800958+00
62	0.448635E 03	0.318180E 03	0.2907838+00
63	0.562507E 03	0.303706E 03	0.4600858+00
64	0.789687E 03	0.300671E 03	0.6192548 00
65	0.134392E 04	0.295542E 03	0.7800858 00
66	0.211844E 04	0.287372E 03	0.8643488 00
67	0.306372E 04	0.285508E 03	0.9068138 00
68	0.395419E 04	0.284700E 03	0.9280008 00
69	0.448533E 04	0.288500E 03	0.9356798 00
70	0.452007E 04	0.289403E 03	0.9359748 00
71	0.388613E 04	0.289698E 03	0.9254538 00
72	0.294213E 04	0.289023E 03	0.9017648 00
73	0.203397E 04	0.290853E 03	0.8570028 00
74	0.130581E 04	0.288486E 03	0.7790758 00
75	0.873365E 03	0.296093E 03	0.6609748 00
76	0.553482E 03	0.296571E 03	0.4641728+00
77	0.423077E 03	0.301590E 03	0.2871518+00
78	0.373890E 03	0.301164E 03	0.1945118+00
79	0.331815E 03	0.304612E 03	0.8198388+01
80	0.333325E 03	0.309869E 03	0.7036978+01
81	0.353877E 03	0.316364E 03	0.1060088+00
82	0.311563E 03	0.317647E 03	+0.1952868+01
83	0.352657E 03	0.316849E 03	0.1015408+00
84	0.325495E 03	0.319290E 03	0.1966478+01
85	0.303317E 03	0.316775E 03	+0.4436898+01
86	0.305745E 03	0.310266E 03	+0.1478528+01
87	0.292557E 03	0.313923E 03	+0.7302858+01
88	0.303115E 03	0.321917E 03	+0.6202888+01
89	0.302255E 03	0.320930E 03	+0.6178588+01
90	0.303277E 03	0.323519E 03	+0.6674248+01
91	0.305292E 03	0.330249E 03	+0.8174728+01
92	0.302195E 03	0.338916E 03	+0.1215148+00
93	0.321182E 03	0.337931E 03	+0.5214738+01
94	0.350060E 03	0.347070E 03	0.8542568+02
95	0.348615E 03	0.355248E 03	+0.1902798+01
96	0.338315E 03	0.358799E 03	+0.6054658+01
97	0.363635E 03	0.360452E 03	0.8752698+02
98	0.346072E 03	0.363311E 03	+0.4981308+01

99	0.351382E 03	0.364969E 03	+0.3866528+01
100	0.398972E 03	0.376643E 03	0.5996668+01
101	0.366097E 03	0.385811E 03	+0.5384728+01
102	0.405210E 03	0.392122E 03	0.3229848+01
103	0.393217E 03	0.404049E 03	+0.2754648+01
104	0.413510E 03	0.408294E 03	0.1261508+01
105	0.385892E 03	0.412478E 03	+0.6689438+01
106	0.393285E 03	0.412599E 03	+0.4918898+01
107	0.387072E 03	0.411828E 03	+0.6395618+01
108	0.380885E 03	0.406548E 03	+0.6737808+01
109	0.372235E 03	0.386238E 03	+0.3761968+01
110	0.341600E 03	0.358747E 03	+0.5019638+01
111	0.281290E 03	0.332726E 03	+0.1828578+00
112	0.254477E 03	0.298140E 03	+0.1715768+00
113	0.216585E 03	0.260459E 03	+0.2025738+00
114	0.170402E 03	0.231896E 03	+0.3608758+00
115	0.181697E 03	0.205917E 03	+0.1332968+00
116	0.155002E 03	0.174160E 03	+0.1235968+00
117	0.128575E 03	0.148477E 03	+0.1547898+00
118	0.988975E 02	0.129662E 03	+0.3381408+00
119	0.823800E 02	0.112873E 03	+0.3701508+00
120	0.837150E 02	0.993121E 02	+0.1863118+00
121	0.754375E 02	0.882404E 02	+0.1697158+00
122	0.757425E 02	0.779091E 02	+0.2860498+01
123	0.751750E 02	0.702174E 02	0.6594698+01
124	0.654150E 02	0.636930E 02	0.2632468+01
125	0.583150E 02	0.628969E 02	+0.7857138+01
126	0.627025E 02	0.760659E 02	+0.2131188+00
127	0.102467E 03	0.996534E 02	0.2746338+01
128	0.151947E 03	0.149111E 03	0.1866758+01
129	0.214392E 03	0.224204E 03	+0.4516218+01
130	0.340302E 03	0.346172E 03	+0.1724938+01
131	0.559600E 03	0.519429E 03	0.7178488+01
132	0.781742E 03	0.767462E 03	0.1826818+01
133	0.100867E 04	0.104802E 04	+0.3900378+01
134	0.139285E 04	0.138226E 04	0.7601978+02
135	0.159396E 04	0.166159E 04	+0.4243088+01
136	0.178508E 04	0.185180E 04	+0.3737448+01
137	0.187352E 04	0.193138E 04	+0.3088458+01
138	0.177173E 04	0.185951E 04	+0.4954278+01
139	0.158321E 04	0.167179E 04	+0.5994428+01
140	0.129145E 04	0.142606E 04	+0.1042338+00
141	0.105752E 04	0.114340E 04	+0.8121448+01
142	0.725605E 03	0.875949E 03	+0.2071988+00
143	0.496477E 03	0.630861E 03	+0.2706748+00
144	0.342562E 03	0.439343E 03	+0.2825198+00
145	0.211560E 03	0.304495E 03	+0.4392858+00
146	0.167185E 03	0.204356E 03	+0.2223368+00
147	0.970150E 02	0.141290E 03	+0.4563658+00
148	0.847775E 02	0.101747E 03	+0.2001618+00
149	0.355900E 02	0.697053E 02	+0.9585658 00
150	0.402275E 02	0.484485E 02	+0.2043648+00
151	0.314400E 02	0.381323E 02	+0.2128608+00
152	0.299100E 02	0.309888E 02	+0.3606668+01
153	0.247875E 02	0.263021E 02	+0.6110318+01
154	0.214575E 02	0.225201E 02	+0.4952348+01
155	0.226275E 02	0.196153E 02	0.1331238+00
156	0.155350E 02	0.180284E 02	+0.1605048+00
157	0.214575E 02	0.180059E 02	0.1608558+00
158	0.154150E 02	0.187815E 02	+0.2183938+00
159	0.128875E 02	0.183678E 02	+0.4252418+00
160	0.168850E 02	0.185770E 02	+0.1062078+00
161	0.228575E 02	0.200763E 02	0.1216768+00
162	0.116575E 02	0.168212E 02	+0.4429518+00
163	0.124600E 02	0.180446E 02	+0.4482048+00
164	0.210125E 02	0.176145E 02	0.1617148+00

165	0.970750E 01	0.185091E 02	-0.9866808 00
166	0.183525E 02	0.177778E 02	0.3131628-01
167	0.758750E 01	0.163632E 02	-0.1156608 01
168	0.983750E 01	0.169308E 02	-0.7210468 00
169	0.121900E 02	0.144423E 02	-0.1847658-00
170	0.113400E 02	0.132042E 02	-0.1643938-00
171	0.135125E 02	0.120513E 02	0.1081408-00
172	0.278500E 01	0.108367E 02	-0.2891118 01
173	0.166500E 01	0.990591E 01	-0.4949508 01
174	0.149200E 02	0.973691E 01	0.3473928-00
175	0.101950E 02	0.958346E 01	0.5998408-01
176	0.110400E 02	0.787238E 01	0.2869228-00
177	0.400500E 01	0.584651E 01	-0.4598028-00
178	0.111025E 02	0.566283E 01	0.4899508-00
179	0.600250E 01	0.548446E 01	0.8630488-01
180	0.800500E 01	0.451545E 01	0.4359218-00
181	0.469000E 01	0.647241E 01	-0.3860458-00
182	0.244000E 01	0.586267E 01	-0.1402738 01
183	0.650250E 01	0.482435E 01	0.2580778-00
184	0.795000E 01	0.551780E 01	0.3059388-00
185	0.135275E 02	0.785976E 01	0.4189798-00
186	0.133825E 02	0.100527E 02	0.2488218-00
187	0.735250E 01	0.128190E 02	-0.7434888 00
188	0.202775E 02	0.181001E 02	0.1073828-00
189	0.273400E 02	0.220763E 02	0.1925288-00
190	0.234600E 02	0.260404E 02	-0.1099908-00
191	0.408600E 02	0.320917E 02	0.2145938-00
192	0.361700E 02	0.352931E 02	0.2424468-01
193	0.315525E 02	0.376005E 02	-0.1916828-00
194	0.338600E 02	0.374521E 02	-0.1060888-00
195	0.291275E 02	0.328885E 02	-0.1291238-00
196	0.161350E 02	0.309664E 02	-0.9192048 00
197	0.202675E 02	0.229553E 02	-0.1326198-00
198	0.214475E 02	0.191854E 02	0.1054738-00
199	0.562000E 01	0.146500E 02	-0.1606778 01
200	0.685750E 01	0.118057E 02	-0.7215748 00
201	0.486000E 01	0.796235E 01	-0.6383448 00
202	0.609750E 01	0.580736E 01	0.4758338-01
203	0.623000E 01	0.478971E 01	0.2311868-00
204	0.247500E-00	0.356303E 01	-0.1339618 02

ZERO DRIFT OF 0.12500 GIVES CHI SQUARE VALUE 0.1618668 03

CORRELATION MATRIX STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
OFF DIAGONAL ELEMENT = GROSS CORRELATION

ROW 1

0.55329E-02

COMPONENT BEING STORED: CS137

GAIN SEARCH FROM 0.95000 TO 1.05000

GAIN SHIFT OF 0.95000 GIVES CHI SQUARE VALUE 0.1636878 03

GAIN SHIFT OF 1.05000 GIVES CHI SQUARE VALUE 0.1572028 03

GAIN SHIFT OF 1.00000 GIVES CHI SQUARE VALUE 0.4230188 01

GAIN SHIFT OF 0.97500 GIVES CHI SQUARE VALUE 0.6880108 02

GAIN SHIFT OF 1.02500 GIVES CHI SQUARE VALUE 0.6324488 02

GAIN SHIFT OF 0.98750 GIVES CHI SQUARE VALUE 0.2363658 02

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GAIN SHIFT OF   1.01250   GIVES CHI SQUARE VALUE   0.2052098 02
GAIN SHIFT OF   0.99375   GIVES CHI SQUARE VALUE   0.9365268 01
GAIN SHIFT OF   1.00625   GIVES CHI SQUARE VALUE   0.7997918 01
GAIN SHIFT OF   0.99687   GIVES CHI SQUARE VALUE   0.5590728 01
USING FUNCTIONAL LIBRARY FROM CHANNEL  40   THROUGH  150
AND USING ELEMENTS    NA 22 CS137

                        RELATIVE INTENSITY VECTOR

          ELEMENT                              INTENSITY

          NA 22                              0.9948768-01
          CS137                              0.1990458-00
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FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE (P+C) ACTUAL-CALCULATED
40	0.101155E 04	0.102287E 04	-0.111854E+01
41	0.107328E 04	0.101847E 04	0.518657E+01
42	0.107811E 04	0.102424E 04	0.499646E+01
43	0.100661E 04	0.102392E 04	-0.171975E+01
44	0.107709E 04	0.103779E 04	0.364947E+01
45	0.106019E 04	0.112222E 04	-0.585095E+01
46	0.131374E 04	0.147646E 04	-0.123877E+00
47	0.202212E 04	0.234203E 04	-0.158205E+00
48	0.358105E 04	0.396769E 04	-0.107968E+00
49	0.592343E 04	0.636204E 04	-0.740473E+01
50	0.913197E 04	0.911486E 04	0.187367E+02
51	0.115659E 05	0.112885E 05	0.239864E+01
52	0.122823E 05	0.119075E 05	0.305180E+01
53	0.110143E 05	0.106111E 05	0.436116E+01
54	0.819101E 04	0.792289E 04	0.327335E+01
55	0.518719E 04	0.504046E 04	0.282883E+01
56	0.292116E 04	0.289314E 04	0.995058E+02
57	0.148432E 04	0.159911E 04	-0.773338E+01
58	0.915410E 03	0.919869E 03	-0.487086E+02
59	0.570025E 03	0.615407E 03	-0.796144E+01
60	0.488760E 03	0.472512E 03	0.332437E+01
61	0.430165E 03	0.419112E 03	0.256940E+01
62	0.448635E 03	0.456889E 03	-0.183979E+01
63	0.562507E 03	0.540398E 03	0.393047E+01
64	0.789687E 03	0.789187E 03	0.633867E+03
65	0.134392E 04	0.127210E 04	0.534381E+01
66	0.211844E 04	0.199403E 04	0.587279E+01
67	0.306372E 04	0.290736E 04	0.510378E+01
68	0.395419E 04	0.386471E 04	0.226306E+01
69	0.448533E 04	0.448787E 04	-0.566081E+03
70	0.452007E 04	0.460372E 04	-0.185075E+01
71	0.388613E 04	0.401401E 04	-0.329060E+01
72	0.294213E 04	0.306849E 04	-0.429490E+01
73	0.203397E 04	0.207866E 04	-0.219718E+01
74	0.130581E 04	0.126860E 04	0.284909E+01
75	0.873365E 03	0.819244E 03	0.619687E+01
76	0.553482E 03	0.544541E 03	0.161553E+01
77	0.423077E 03	0.396725E 03	0.622880E+01
78	0.373890E 03	0.331135E 03	0.114351E+00
79	0.331815E 03	0.311281E 03	0.618848E+01
80	0.333325E 03	0.305060E 03	0.847973E+01
81	0.353877E 03	0.301578E 03	0.147788E+00
82	0.311563E 03	0.299502E 03	0.387093E+01
83	0.352657E 03	0.298445E 03	0.153725E+00
84	0.325495E 03	0.300744E 03	0.760401E+01
85	0.303317E 03	0.298376E 03	0.162909E+01
86	0.305745E 03	0.292244E 03	0.441563E+01
87	0.292557E 03	0.295689E 03	-0.107040E+01
88	0.303115E 03	0.303219E 03	-0.343281E+03
89	0.302255E 03	0.302990E 03	-0.114370E+03
90	0.303277E 03	0.304728E 03	-0.478304E+02
91	0.305292E 03	0.311068E 03	-0.189163E+01
92	0.302195E 03	0.319231E 03	-0.563730E+01
93	0.321182E 03	0.318303E 03	0.896435E+02
94	0.350060E 03	0.326911E 03	0.661291E+01
95	0.348615E 03	0.334615E 03	0.401601E+01
96	0.338315E 03	0.337959E 03	0.105295E+02
97	0.363635E 03	0.339516E 03	0.663271E+01
98	0.346072E 03	0.342209E 03	0.111631E+01

99	0.351382E 03	0.343770E 03	0.2166338+01
100	0.398972E 03	0.354767E 03	0.1107998+00
101	0.366097E 03	0.363402E 03	0.7363198+02
102	0.405210E 03	0.369347E 03	0.8850518+01
103	0.393217E 03	0.380581E 03	0.3213638+01
104	0.413510E 03	0.384579E 03	0.6996508+01
105	0.385892E 03	0.388520E 03	-0.6810008+02
106	0.393285E 03	0.388634E 03	0.1182628+01
107	0.387072E 03	0.387908E 03	-0.2198618+02
108	0.380885E 03	0.382935E 03	-0.5381788+02
109	0.372235E 03	0.363805E 03	0.2264828+01
110	0.341600E 03	0.337910E 03	0.1080208+01
111	0.281290E 03	0.313400E 03	-0.1141538+00
112	0.254477E 03	0.280823E 03	-0.1035288+00
113	0.216585E 03	0.245331E 03	-0.1327258+00
114	0.170402E 03	0.218427E 03	-0.2818318+00
115	0.181697E 03	0.193957E 03	-0.6747148+01
116	0.155002E 03	0.164044E 03	-0.5833448+01
117	0.128575E 03	0.139853E 03	-0.8771538+01
118	0.968975E 02	0.122131E 03	-0.2604178+00
119	0.823800E 02	0.106317E 03	-0.2905688+00
120	0.837150E 02	0.935437E 02	-0.1174078+00
121	0.754375E 02	0.831152E 02	-0.1017758+00
122	0.757425E 02	0.733839E 02	0.3113938+01
123	0.751750E 02	0.661396E 02	0.1201998+00
124	0.654150E 02	0.599935E 02	0.8287848+01
125	0.583150E 02	0.592437E 02	-0.1592498+01
126	0.627025E 02	0.716474E 02	-0.1426578+00
127	0.102467E 03	0.938653E 02	0.8395108+01
128	0.151947E 03	0.140450E 03	0.7566608+01
129	0.214392E 03	0.211181E 03	0.1497868+01
130	0.340302E 03	0.326066E 03	0.4183538+01
131	0.559600E 03	0.489259E 03	0.1256988+00
132	0.781742E 03	0.722885E 03	0.7528988+01
133	0.100867E 04	0.987145E 03	0.2134458+01
134	0.139285E 04	0.130198E 04	0.6524328+01
135	0.159396E 04	0.156508E 04	0.1811648+01
136	0.178508E 04	0.174424E 04	0.2287928+01
137	0.187352E 04	0.181920E 04	0.2899228+01
138	0.177173E 04	0.175150E 04	0.1141768+01
139	0.158321E 04	0.157468E 04	0.5387978+02
140	0.129145E 04	0.134323E 04	-0.4009658+01
141	0.105752E 04	0.107699E 04	-0.1841458+01
142	0.725605E 03	0.825071E 03	-0.1370818+00
143	0.496477E 03	0.594219E 03	-0.1968708+00
144	0.342562E 03	0.413825E 03	-0.2080278+00
145	0.211560E 03	0.286809E 03	-0.3556888+00
146	0.167185E 03	0.192487E 03	-0.1513398+00
147	0.970150E 02	0.133083E 03	-0.3717798+00
148	0.847775E 02	0.958369E 02	-0.1304528+00
149	0.355900E 02	0.656567E 02	-0.8448068 00
150	0.402275E 02	0.456345E 02	-0.1344118+00

GAIN SHIFT OF 1.00156 GIVES CHI SQUARE VALUE 0.4238858 01

ZERO SEARCH FROM -2.00000 TO 2.00000

ZERO DRIFT OF -2.00000 GIVES CHI SQUARE VALUE 0.7773518 02

ZERO DRIFT OF 2.00000 GIVES CHI SQUARE VALUE 0.8529888 02

ZERO DRIFT OF 0. GIVES CHI SQUARE VALUE 0.4238858 01

ZERO DRIFT OF -1.00000 GIVES CHI SQUARE VALUE 0.2415108 02

ZERO DRIFT OF 1.00000 GIVES CHI SQUARE VALUE 0.3080268 02

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ZERO DRIFT OF  -0.50000   GIVES CHI SQUARE VALUE   0.8372316 01
ZERO DRIFT OF   0.50000   GIVES CHI SQUARE VALUE   0.1215728 02
ZERO DRIFT OF  -0.25000   GIVES CHI SQUARE VALUE   0.4715648 01
ZERO DRIFT OF   0.25000   GIVES CHI SQUARE VALUE   0.6642558 01
ZERO DRIFT OF  -0.12500   GIVES CHI SQUARE VALUE   0.4075998 01
ZERO DRIFT OF  -0.06250   GIVES CHI SQUARE VALUE   0.4057528 01
ZERO DRIFT OF  -0.09375   GIVES CHI SQUARE VALUE   0.4041698 01
ZERO DRIFT OF  -0.07813   GIVES CHI SQUARE VALUE   0.4043348 01
ZERO DRIFT OF  -0.10938   GIVES CHI SQUARE VALUE   0.4052568 01
ZERO DRIFT OF  -0.08594   GIVES CHI SQUARE VALUE   0.4040958 01
ZERO DRIFT OF  -0.08984   GIVES CHI SQUARE VALUE   0.4040938 01
USING FUNCTIONAL LIBRARY FROM CHANNEL  40   THROUGH  150
AND USING ELEMENTS    NA 22 CS137
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RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
NA 22	0.9994919E+01
CS137	0.1994888+00

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE (P,C,) ACTUAL-CALCULATED
40	0.101155E 04	0.102482E 04	-0.1311018-01
41	0.107328E 04	0.102011E 04	0.4954068-01
42	0.107811E 04	0.102370E 04	0.5047028-01
43	0.100661E 04	0.102247E 04	-0.1575068-01
44	0.107709E 04	0.103359E 04	0.4042478-01
45	0.106019E 04	0.111705E 04	-0.5363368-01
46	0.131374E 04	0.147087E 04	-0.1196038-00
47	0.202212E 04	0.233846E 04	-0.1564408-00
48	0.358105E 04	0.396393E 04	-0.1069188-00
49	0.592343E 04	0.635967E 04	-0.7364698-01
50	0.913197E 04	0.911346E 04	0.2027218-02
51	0.115659E 05	0.112878E 05	0.2404408-01
52	0.122823E 05	0.119070E 05	0.3055778-01
53	0.110143E 05	0.106108E 05	0.3663908-01
54	0.819101E 04	0.792312E 04	0.3270468-01
55	0.518719E 04	0.504053E 04	0.2827548-01
56	0.292116E 04	0.289276E 04	0.9722568-02
57	0.148432E 04	0.159888E 04	-0.7717848-01
58	0.915410E 03	0.920939E 03	-0.6040308-02
59	0.570025E 03	0.615352E 03	-0.7951778-01
60	0.488760E 03	0.473968E 03	0.3026528-01
61	0.430165E 03	0.425649E 03	0.1049798-01
62	0.448635E 03	0.465999E 03	-0.3870498-01
63	0.562507E 03	0.563637E 03	-0.2007878-02
64	0.789687E 03	0.834246E 03	-0.5642508-01
65	0.134392E 04	0.134003E 04	0.2895498-02
66	0.211844E 04	0.208028E 04	0.1801368-01
67	0.306372E 04	0.299952E 04	0.2095578-01
68	0.395419E 04	0.392852E 04	0.6491448-02
69	0.448533E 04	0.450764E 04	-0.4972388-02
70	0.452007E 04	0.456026E 04	-0.8892538-02
71	0.388613E 04	0.393728E 04	-0.1316118-01
72	0.294213E 04	0.298545E 04	-0.1472488-01
73	0.203397E 04	0.200996E 04	0.1180748-01
74	0.130581E 04	0.122973E 04	0.5826088-01
75	0.873365E 03	0.795684E 03	0.8805442E-01
76	0.553482E 03	0.531408E 03	0.3988238-01
77	0.423077E 03	0.391118E 03	0.7553968-01
78	0.373890E 03	0.329173E 03	0.1195598-00
79	0.331815E 03	0.310341E 03	0.6471578-01
80	0.333325E 03	0.304238E 03	0.8726418-01
81	0.353877E 03	0.301304E 03	0.1485658-00
82	0.311563E 03	0.299488E 03	0.3875378-01
83	0.352657E 03	0.298458E 03	0.1536888-00
84	0.325495E 03	0.300757E 03	0.7600018-01
85	0.303317E 03	0.298389E 03	0.1624838-01
86	0.305745E 03	0.292257E 03	0.4411498-01
87	0.292557E 03	0.295702E 03	-0.1074788-01
88	0.303115E 03	0.303232E 03	-0.3866118-03
89	0.302255E 03	0.302303E 03	-0.1576978-03
90	0.303277E 03	0.304741E 03	-0.4826578-02
91	0.305292E 03	0.311081E 03	-0.1896058-01
92	0.302195E 03	0.319244E 03	-0.5641888-01
93	0.321182E 03	0.318317E 03	0.8921418-02
94	0.350060E 03	0.326925E 03	0.6608878-01
95	0.348615E 03	0.334629E 03	0.4011858-01
96	0.338315E 03	0.337973E 03	0.1089668-02
97	0.363635E 03	0.339531E 03	0.6628668-01
98	0.346072E 03	0.342224E 03	0.1112028-01

99	0.351382E 03	0.343785E 03	0.216205E+01
100	0.398972E 03	0.354782E 03	0.110760E+00
101	0.366097E 03	0.363418E 03	0.732018E+02
102	0.405210E 03	0.369363E 03	0.884656E+01
103	0.393217E 03	0.380597E 03	0.320944E+01
104	0.413510E 03	0.384595E 03	0.699247E+01
105	0.385892E 03	0.388537E 03	-0.685363E+02
106	0.393285E 03	0.388651E 03	0.117834E+01
107	0.387072E 03	0.387925E 03	-0.220202E+02
108	0.380885E 03	0.382951E 03	-0.542534E+02
109	0.372235E 03	0.363820E 03	0.226059E+01
110	0.341600E 03	0.337925E 03	0.107591E+01
111	0.281290E 03	0.313414E 03	-0.114201E+00
112	0.254477E 03	0.280835E 03	-0.103575E+00
113	0.216585E 03	0.245342E 03	-0.132774E+00
114	0.170402E 03	0.218437E 03	-0.281887E+00
115	0.181697E 03	0.193965E 03	-0.675177E+01
116	0.155002E 03	0.164052E 03	-0.583802E+01
117	0.128575E 03	0.139859E 03	-0.877624E+01
118	0.968975E 02	0.122137E 03	-0.260472E+00
119	0.823800E 02	0.106322E 03	-0.290623E+00
120	0.837150E 02	0.935478E 02	-0.117456E+00
121	0.754375E 02	0.831188E 02	-0.101823E+00
122	0.757425E 02	0.733871E 02	0.310973E+01
123	0.751750E 02	0.661419E 02	0.120161E+00
124	0.654150E 02	0.599961E 02	0.828386E+01
125	0.583150E 02	0.592462E 02	-0.159685E+01
126	0.627025E 02	0.716506E 02	-0.142706E+00
127	0.102467E 03	0.938693E 02	0.839113E+01
128	0.151947E 03	0.140456E 03	0.756260E+01
129	0.214392E 03	0.211190E 03	0.149359E+01
130	0.340302E 03	0.326080E 03	0.417938E+01
131	0.559600E 03	0.489281E 03	0.125660E+00
132	0.781742E 03	0.722917E 03	0.752497E+01
133	0.100867E 04	0.987188E 03	0.213021E+01
134	0.139285E 04	0.130203E 04	0.652027E+01
135	0.159396E 04	0.156515E 04	0.180739E+01
136	0.178508E 04	0.174432E 04	0.228369E+01
137	0.187352E 04	0.181928E 04	0.285501E+01
138	0.177173E 04	0.175158E 04	0.113748E+01
139	0.158321E 04	0.157475E 04	0.534488E+02
140	0.129145E 04	0.134329E 04	-0.401416E+01
141	0.105752E 04	0.107704E 04	-0.184586E+01
142	0.725605E 03	0.825107E 03	-0.137130E+00
143	0.496477E 03	0.594245E 03	-0.196922E+00
144	0.342562E 03	0.413843E 03	-0.208079E+00
145	0.211560E 03	0.286822E 03	-0.355746E+00
146	0.167185E 03	0.192495E 03	-0.151389E+00
147	0.970150E 02	0.133089E 03	-0.371839E+00
148	0.847775E 02	0.958411E 02	-0.130501E+00
149	0.355900E 02	0.656595E 02	-0.844886E 00
150	0.402275E 02	0.456365E 02	-0.134460E+00

ZERO DRIFT OF -0.08984 GIVES CHI SQUARE VALUE 0.404093E 01

CORRELATION MATRIX STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
OFF DIAGONAL ELEMENT = GROSS CORRELATION

ROW 1

0.88352E-03

ROW 2

0.15412E-01 0.35149E-02

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COMPONENT BEING STORED:  CO 57
GAIN SEARCH FROM    0.95000 TO    1.05000
GAIN SHIFT OF   0.95000   GIVES CHI SQUARE VALUE   0.5289648 02
GAIN SHIFT OF   1.05000   GIVES CHI SQUARE VALUE   0.3313588 02
GAIN SHIFT OF   1.00000   GIVES CHI SQUARE VALUE   0.1366718 02
GAIN SHIFT OF   0.97500   GIVES CHI SQUARE VALUE   0.2541618 02
GAIN SHIFT OF   1.02500   GIVES CHI SQUARE VALUE   0.1036748 02
GAIN SHIFT OF   1.01250   GIVES CHI SQUARE VALUE   0.8261348 01
GAIN SHIFT OF   1.01875   GIVES CHI SQUARE VALUE   0.8412138 01
GAIN SHIFT OF   1.00625   GIVES CHI SQUARE VALUE   0.1000628 02
GAIN SHIFT OF   1.01562   GIVES CHI SQUARE VALUE   0.8104388 01
USING FUNCTIONAL LIBRARY FROM CHANNEL   2   THROUGH  204
AND USING ELEMENTS    NA 22 CS137 CO 57

                    RELATIVE INTENSITY VECTOR

          ELEMENT                          INTENSITY
          NA 22                        0.1004678+00
          CS137                        0.2023208+00
          CO 57                        0.1941478+00
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FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE (ACTUAL-CALCULATED)
2	0.397917E 04	0.196757E 04	0.5055318 00
3	0.785757E 04	0.707825E 04	0.9918028+01
4	0.888432E 04	0.885335E 04	0.3486378+02
5	0.246904E 05	0.259525E 05	-0.5111568+01
6	0.478824E 05	0.472244E 05	0.1374198+01
7	0.169392E 05	0.172828E 05	-0.2028178+01
8	0.544642E 04	0.539245E 04	0.9909548+02
9	0.305766E 04	0.290025E 04	0.5148058+01
10	0.271741E 04	0.267183E 04	0.1677418+01
11	0.279809E 04	0.267090E 04	0.4545788+01
12	0.272900E 04	0.260335E 04	0.4604528+01
13	0.250535E 04	0.252197E 04	-0.6631358+02
14	0.238601E 04	0.245720E 04	-0.2983618+01
15	0.237329E 04	0.239841E 04	-0.1058138+01
16	0.243780E 04	0.234175E 04	0.3939598+01
17	0.230276E 04	0.230221E 04	0.2396878+03
18	0.227871E 04	0.229223E 04	-0.5935328+02
19	0.231568E 04	0.225080E 04	0.2802058+01
20	0.233575E 04	0.221299E 04	0.5255638+01
21	0.225350E 04	0.218039E 04	0.3246388+01
22	0.226605E 04	0.216536E 04	0.4443258+01
23	0.216460E 04	0.211116E 04	-0.3028748+02
24	0.217899E 04	0.218079E 04	-0.8292738+03
25	0.214263E 04	0.216929E 04	-0.1244338+01
26	0.218929E 04	0.215916E 04	0.1376468+01
27	0.210114E 04	0.210405E 04	-0.1385288+02
28	0.205077E 04	0.200192E 04	0.2382508+01
29	0.189787E 04	0.185261E 04	0.4492398+01
30	0.166732E 04	0.164050E 04	0.1608408+01
31	0.155993E 04	0.144036E 04	0.7665258+01
32	0.134553E 04	0.130133E 04	0.3285148+01
33	0.130315E 04	0.119886E 04	0.8003248+01
34	0.116818E 04	0.113677E 04	0.2689638+01
35	0.121214E 04	0.110202E 04	0.9084888+01
36	0.108925E 04	0.101137E 04	-0.1112898+01
37	0.111094E 04	0.107341E 04	0.3378388+01
38	0.101855E 04	0.107351E 04	-0.5396618+01
39	0.102907E 04	0.104226E 04	-0.1281588+01
40	0.101155E 04	0.103712E 04	-0.2527478+01
41	0.107328E 04	0.103240E 04	0.3808448+01
42	0.107811E 04	0.103604E 04	0.3902118+01
43	0.100661E 04	0.103471E 04	-0.2791258+01
44	0.107709E 04	0.104576E 04	0.2908758+01
45	0.106019E 04	0.112982E 04	-0.6567418+01
46	0.131374E 04	0.148680E 04	-0.1317288+00
47	0.202212E 04	0.236258E 04	-0.1683708+00
48	0.358105E 04	0.400377E 04	-0.1180438+00
49	0.592343E 04	0.642277E 04	-0.8429918+01
50	0.913197E 04	0.920339E 04	-0.7820708+02
51	0.115659E 05	0.113990E 05	0.1443548+01
52	0.122823E 05	0.120242E 05	0.2102148+01
53	0.110143E 05	0.107152E 05	0.2716318+01
54	0.819101E 04	0.800112E 04	0.2318268+01
55	0.518719E 04	0.509027E 04	0.1868638+01
56	0.292116E 04	0.292144E 04	-0.9595658+04
57	0.148432E 04	0.161485E 04	-0.8793978+01
58	0.915410E 03	0.930259E 03	-0.1621638+01
59	0.570025E 03	0.621712E 03	-0.9067498+01
60	0.488760E 03	0.478937E 03	0.2009758+01

61	0.430165E 03	0.430230E 03	+0.1506948+03
62	0.448635E 03	0.471296E 03	+0.5051008+01
63	0.562507E 03	0.570379E 03	+0.1399318+01
64	0.789687E 03	0.844840E 03	+0.6984158+01
65	0.134392E 04	0.135782E 04	+0.1034508+01
66	0.211844E 04	0.210862E 04	0.4638798+02
67	0.306372E 04	0.304091E 04	0.7446838+02
68	0.395419E 04	0.398310E 04	+0.7310448+02
69	0.448533E 04	0.457041E 04	+0.1896878+01
70	0.452007E 04	0.462378E 04	+0.2294578+01
71	0.388613E 04	0.399196E 04	+0.2723138+01
72	0.294213E 04	0.302662E 04	+0.2871928+01
73	0.203397E 04	0.203728E 04	+0.1625088+02
74	0.130581E 04	0.124599E 04	0.4581028+01
75	0.873365E 03	0.805751E 03	0.7741818+01
76	0.553482E 03	0.537722E 03	0.2847468+01
77	0.423077E 03	0.395421E 03	0.6537098+01
78	0.373890E 03	0.332598E 03	0.1104398+00
79	0.331815E 03	0.313485E 03	0.5524288+01
80	0.333325E 03	0.307273E 03	0.7815938+01
81	0.353877E 03	0.304270E 03	0.1401838+00
82	0.311563E 03	0.302424E 03	0.2933268+01
83	0.352657E 03	0.301382E 03	0.1453978+00
84	0.325495E 03	0.303704E 03	0.6694788+01
85	0.303317E 03	0.301312E 03	0.6610678+02
86	0.305745E 03	0.295120E 03	0.3475038+01
87	0.292557E 03	0.298599E 03	+0.2064998+01
88	0.303115E 03	0.306203E 03	+0.1018728+01
89	0.302255E 03	0.305264E 03	+0.9956068+02
90	0.303277E 03	0.307727E 03	+0.1467078+01
91	0.305292E 03	0.314125E 03	+0.2894308+01
92	0.302195E 03	0.322372E 03	+0.6676838+01
93	0.321182E 03	0.321436E 03	+0.7880068+03
94	0.356060E 03	0.330128E 03	0.5693938+01
95	0.348615E 03	0.337907E 03	0.3071478+01
96	0.338315E 03	0.341284E 03	+0.8777278+02
97	0.363635E 03	0.342857E 03	0.5713928+01
98	0.346072E 03	0.345577E 03	0.1432348+02
99	0.351382E 03	0.347153E 03	0.1203598+01
100	0.398972E 03	0.358258E 03	0.1020488+00
101	0.366097E 03	0.366978E 03	+0.2404928+02
102	0.405210E 03	0.372981E 03	0.7953558+01
103	0.393217E 03	0.384326E 03	0.2261208+01
104	0.413510E 03	0.388363E 03	0.6081298+01
105	0.385892E 03	0.392344E 03	+0.1671768+01
106	0.393285E 03	0.392458E 03	0.2102028+02
107	0.387072E 03	0.391725E 03	+0.1202048+01
108	0.380885E 03	0.386703E 03	+0.1527538+01
109	0.372235E 03	0.367385E 03	0.1303058+01
110	0.341600E 03	0.341235E 03	0.1067698+02
111	0.281290E 03	0.316484E 03	+0.1251178+00
112	0.254477E 03	0.283586E 03	+0.1143878+00
113	0.216585E 03	0.247745E 03	+0.1438718+00
114	0.170402E 03	0.220577E 03	+0.2944458+00
115	0.181697E 03	0.195866E 03	+0.7797608+01
116	0.155002E 03	0.165659E 03	+0.6874908+01
117	0.128575E 03	0.141229E 03	+0.9841908+01
118	0.968975E 02	0.123333E 03	+0.2728208+00
119	0.823800E 02	0.107363E 03	+0.3032678+00
120	0.837150E 02	0.944643E 02	+0.1284038+00
121	0.754375E 02	0.839331E 02	+0.1126178+00
122	0.757425E 02	0.741061E 02	0.2160528+01
123	0.751750E 02	0.667899E 02	0.1115428+00
124	0.654150E 02	0.605839E 02	0.7385348+01
125	0.583150E 02	0.598267E 02	+0.2592228+01
126	0.627025E 02	0.723525E 02	+0.1539018+00

127	0.102467E 03	0.947889E 02	0.7493658+01
128	0.151947E 03	0.141832E 03	0.6657008+01
129	0.214392E 03	0.213259E 03	0.5285448+02
130	0.340302E 03	0.329274E 03	0.3240658+01
131	0.559600E 03	0.494074E 03	0.1170948+00
132	0.781742E 03	0.729999E 03	0.6619018+01
133	0.100867E 04	0.996859E 03	0.1171408+01
134	0.139285E 04	0.131479E 04	0.5604478+01
135	0.159396E 04	0.158048E 04	0.8494148+02
136	0.178508E 04	0.176141E 04	0.1326388+01
137	0.187352E 04	0.183710E 04	0.1943658+01
138	0.177173E 04	0.176874E 04	0.1689408+02
139	0.158321E 04	0.159018E 04	-0.4399588+02
140	0.129145E 04	0.135645E 04	-0.5033178+01
141	0.105752E 04	0.108759E 04	-0.2843638+01
142	0.725605E 03	0.833191E 03	-0.1482708+00
143	0.496477E 03	0.600066E 03	-0.2086488+00
144	0.342562E 03	0.417897E 03	-0.2199148+00
145	0.211560E 03	0.289632E 03	-0.3690288+00
146	0.167185E 03	0.194381E 03	-0.1626698+00
147	0.970150E 02	0.134393E 03	-0.3852788+00
148	0.847775E 02	0.967808E 02	-0.1415778+00
149	0.355900E 02	0.663028E 02	-0.8629608 00
150	0.402275E 02	0.460836E 02	-0.1455748+00
151	0.314400E 02	0.362710E 02	-0.1536568+00
152	0.299100E 02	0.294761E 02	0.1450778+01
153	0.247875E 02	0.250182E 02	-0.9306688+02
154	0.214575E 02	0.214209E 02	0.1707808+02
155	0.226275E 02	0.186578E 02	0.1754398+00
156	0.155350E 02	0.171484E 02	-0.1038558+00
157	0.214575E 02	0.171270E 02	0.2018178+00
158	0.154150E 02	0.178647E 02	-0.1589198+00
159	0.128875E 02	0.174712E 02	-0.3556708+00
160	0.168850E 02	0.176702E 02	-0.4650168+01
161	0.228575E 02	0.190963E 02	0.1645508+00
162	0.116575E 02	0.160001E 02	-0.3725158+00
163	0.124600E 02	0.171638E 02	-0.3775118+00
164	0.210125E 02	0.167547E 02	0.2026348+00
165	0.970750E 01	0.176056E 02	-0.8136088 00
166	0.183525E 02	0.169100E 02	0.7860138+01
167	0.758750E 01	0.155644E 02	-0.1051338 01
168	0.983750E 01	0.161043E 02	-0.6370358 00
169	0.121900E 02	0.137373E 02	-0.1269328+00
170	0.113400E 02	0.125597E 02	-0.1079558+00
171	0.135125E 02	0.114630E 02	0.1516758+00
172	0.278500E 01	0.103077E 02	-0.2701178 01
173	0.166500E 01	0.942237E 01	-0.4659088 01
174	0.149200E 02	0.926162E 01	0.3792468+00
175	0.101950E 02	0.911566E 01	0.1058708+00
176	0.110400E 02	0.748810E 01	0.3217308+00
177	0.400500E 01	0.556112E 01	-0.3885438+00
178	0.111025E 02	0.538641E 01	0.5148478 00
179	0.600250E 01	0.521674E 01	0.1309068+00
180	0.800500E 01	0.429503E 01	0.4634568+00
181	0.469000E 01	0.615647E 01	-0.3126808+00
182	0.244000E 01	0.557649E 01	-0.1285458 01
183	0.650250E 01	0.458886E 01	0.2942938+00
184	0.795000E 01	0.524845E 01	0.3398178+00
185	0.135275E 02	0.747610E 01	0.4413418+00
186	0.133825E 02	0.956195E 01	0.2854898+00
187	0.735250E 01	0.121933E 02	-0.6583828 00
188	0.202775E 02	0.172165E 02	0.1509548+00
189	0.273400E 02	0.209986E 02	0.2319448+00
190	0.234600E 02	0.247692E 02	-0.5580758+01
191	0.408600E 02	0.305252E 02	0.2529328+00
192	0.361700E 02	0.335703E 02	0.7187498+01

193	0.315925E 02	0.357651E 02	-0.1335118-00
194	0.338600E 02	0.356239E 02	-0.5209538-01
195	0.291275E 02	0.312831E 02	-0.7400588-01
196	0.161350E 02	0.294548E 02	-0.8255218 00
197	0.202675E 02	0.218348E 02	-0.7733148-01
198	0.214475E 02	0.182489E 02	0.1491388-00
199	0.562000E 01	0.139349E 02	-0.1479528 01
200	0.685750E 01	0.112294E 02	-0.6375388 00
201	0.486000E 01	0.757368E 01	-0.5583718 00
202	0.609750E 01	0.552388E 01	0.9407438-01
203	0.623000E 01	0.455591E 01	0.2687158-00
204	0.247500E-00	0.338910E 01	-0.1269338 02

GAIN SHIFT OF 1.01562 GIVES CHI SQUARE VALUE 0.8104388 01

ZERO SEARCH FROM -2.00000 TO 2.00000

ZERO DRIFT OF -2.00000 GIVES CHI SQUARE VALUE 0.3458198 03

ZERO DRIFT OF 2.00000 GIVES CHI SQUARE VALUE 0.3722268 03

ZERO DRIFT OF 0. GIVES CHI SQUARE VALUE 0.8104388 01

ZERO DRIFT OF -1.00000 GIVES CHI SQUARE VALUE 0.2199578 03

ZERO DRIFT OF 1.00000 GIVES CHI SQUARE VALUE 0.2485868 03

ZERO DRIFT OF -0.50000 GIVES CHI SQUARE VALUE 0.8876018 02

ZERO DRIFT OF 0.50000 GIVES CHI SQUARE VALUE 0.1092988 03

ZERO DRIFT OF -0.25000 GIVES CHI SQUARE VALUE 0.3022498 02

ZERO DRIFT OF 0.25000 GIVES CHI SQUARE VALUE 0.3834148 02

ZERO DRIFT OF -0.12500 GIVES CHI SQUARE VALUE 0.1339598 02

ZERO DRIFT OF 0.12500 GIVES CHI SQUARE VALUE 0.1621988 02

ZERO DRIFT OF -0.06250 GIVES CHI SQUARE VALUE 0.9246268 01

ZERO DRIFT OF 0.06250 GIVES CHI SQUARE VALUE 0.1029518 02

ZERO DRIFT OF -0.03125 GIVES CHI SQUARE VALUE 0.8298918 01

ZERO DRIFT OF 0.03125 GIVES CHI SQUARE VALUE 0.8729568 01

ZERO DRIFT OF -0.01563 GIVES CHI SQUARE VALUE 0.8107958 01

ZERO DRIFT OF 0.01563 GIVES CHI SQUARE VALUE 0.8299718 01

ZERO DRIFT OF -0.00781 GIVES CHI SQUARE VALUE 0.8082828 01

ZERO DRIFT OF -0.00391 GIVES CHI SQUARE VALUE 0.8087788 01

ZERO DRIFT OF -0.01172 GIVES CHI SQUARE VALUE 0.8089548 01

USING FUNCTIONAL LIBRARY FROM CHANNEL 2 THROUGH 204

AND USING ELEMENTS NA 22 CS137 CO 57

RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY

NA 22	0.1004488+00
CS137	0.2022798+00
CO 57	0.1942858+00

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE (P,C,) ACTUAL-CALCULATED
2	0.397917E 04	0.199722E 04	0.458080E+00
3	0.785757E 04	0.709277E 04	0.973329E+01
4	0.888432E 04	0.899097E 04	+0.120044E+01
5	0.246904E 05	0.261351E 05	+0.585147E+01
6	0.478824E 05	0.470228E 05	0.179533E+01
7	0.169392E 05	0.172002E 05	+0.154081E+01
8	0.546642E 04	0.537417E 04	0.132649E+01
9	0.305766E 04	0.289761E 04	0.523460E+01
10	0.271741E 04	0.267114E 04	0.170306E+01
11	0.279809E 04	0.267038E 04	0.456426E+01
12	0.272900E 04	0.260286E 04	0.462228E+01
13	0.250535E 04	0.252150E 04	+0.644355E+02
14	0.238601E 04	0.245674E 04	+0.296441E+01
15	0.237329E 04	0.239796E 04	+0.103931E+01
16	0.243780E 04	0.234132E 04	0.395786E+01
17	0.230276E 04	0.230178E 04	0.425700E+03
18	0.227871E 04	0.229181E 04	+0.574804E+02
19	0.231568E 04	0.225038E 04	0.282014E+01
20	0.233575E 04	0.221258E 04	0.527326E+01
21	0.225350E 04	0.217994E 04	0.326438E+01
22	0.226605E 04	0.216496E 04	0.446103E+01
23	0.216460E 04	0.217076E 04	+0.284195E+02
24	0.217899E 04	0.218039E 04	+0.643016E+03
25	0.214263E 04	0.216889E 04	+0.122552E+01
26	0.218929E 04	0.215876E 04	0.139478E+01
27	0.210114E 04	0.210366E 04	+0.119923E+02
28	0.205077E 04	0.200154E 04	0.240067E+01
29	0.189787E 04	0.181227E 04	0.451019E+01
30	0.166732E 04	0.164019E 04	0.162680E+01
31	0.155993E 04	0.144008E 04	0.768257E+01
32	0.134553E 04	0.130108E 04	0.330334E+01
33	0.130315E 04	0.119863E 04	0.802060E+01
34	0.116818E 04	0.113659E 04	0.270803E+01
35	0.121214E 04	0.110181E 04	0.910210E+01
36	0.108925E 04	0.110116E 04	+0.109368E+01
37	0.111094E 04	0.107320E 04	0.339676E+01
38	0.101855E 04	0.107331E 04	+0.537651E+01
39	0.102907E 04	0.104206E 04	+0.126227E+01
40	0.101155E 04	0.103692E 04	+0.250790E+01
41	0.107328E 04	0.103221E 04	0.382681E+01
42	0.107811E 04	0.103589E 04	0.392048E+01
43	0.100661E 04	0.103451E 04	+0.277165E+01
44	0.107709E 04	0.104557E 04	0.292719E+01
45	0.106019E 04	0.112960E 04	+0.654734E+01
46	0.131374E 04	0.148652E 04	+0.131518E+00
47	0.202212E 04	0.236219E 04	+0.168156E+00
48	0.358105E 04	0.400304E 04	+0.117839E+00
49	0.592343E 04	0.642160E 04	+0.841022E+01
50	0.913197E 04	0.920172E 04	+0.763794E+02
51	0.115659E 05	0.113969E 05	0.146141E+01
52	0.122823E 05	0.120220E 05	0.211988E+01
53	0.110143E 05	0.107132E 05	0.273394E+01
54	0.819101E 04	0.799967E 04	0.233596E+01
55	0.518719E 04	0.508934E 04	0.188642E+01
56	0.292116E 04	0.292091E 04	0.856034E+04
57	0.148432E 04	0.161456E 04	+0.877418E+01
58	0.915410E 03	0.930085E 03	+0.160309E+01
59	0.570025E 03	0.621598E 03	+0.904748E+01
60	0.488760E 03	0.478849E 03	0.202783E+01

61	0.430165E 03	0.430150E 03	0.346472E+04
62	0.448635E 03	0.471207E 03	-0.503125E+01
63	0.562507E 03	0.570270E 03	-0.137998E+01
64	0.789687E 03	0.844617E 03	-0.696340E+01
65	0.134392E 04	0.135756E 04	-0.101465E+01
66	0.211844E 04	0.210820E 04	0.483589E+02
67	0.306372E 04	0.304031E 04	0.764415E+02
68	0.395419E 04	0.398231E 04	-0.710976E+02
69	0.448533E 04	0.456950E 04	-0.187656E+01
70	0.452007E 04	0.462286E 04	-0.227418E+01
71	0.388613E 04	0.399116E 04	-0.270267E+01
72	0.294213E 04	0.302602E 04	-0.285147E+01
73	0.203397E 04	0.203687E 04	-0.142685E+02
74	0.130581E 04	0.124574E 04	0.459975E+01
75	0.873365E 03	0.805595E 03	0.775968E+01
76	0.553482E 03	0.537620E 03	0.286595E+01
77	0.423077E 03	0.395347E 03	0.655451E+01
78	0.373890E 03	0.332537E 03	0.110603E+00
79	0.331815E 03	0.313427E 03	0.554152E+01
80	0.333325E 03	0.307217E 03	0.783269E+01
81	0.353877E 03	0.304215E 03	0.140339E+00
82	0.311563E 03	0.302369E 03	0.295083E+01
83	0.352657E 03	0.301328E 03	0.145552E+00
84	0.325495E 03	0.303649E 03	0.671167E+01
85	0.303317E 03	0.301258E 03	0.679049E+02
86	0.305745E 03	0.295067E 03	0.349250E+01
87	0.292557E 03	0.298549E 03	-0.204652E+01
88	0.303115E 03	0.306147E 03	-0.100044E+01
89	0.302255E 03	0.305209E 03	-0.977325E+02
90	0.303277E 03	0.307671E 03	-0.144870E+01
91	0.305292E 03	0.314072E 03	-0.287568E+01
92	0.302195E 03	0.322314E 03	-0.665752E+01
93	0.321182E 03	0.321377E 03	-0.606845E+03
94	0.350060E 03	0.330068E 03	0.571160E+01
95	0.348615E 03	0.337846E 03	0.308901E+01
96	0.338315E 03	0.341223E 03	-0.859466E+02
97	0.363635E 03	0.342795E 03	0.573099E+01
98	0.346072E 03	0.345514E 03	0.161309E+02
99	0.351382E 03	0.347090E 03	0.122148E+01
100	0.398972E 03	0.358193E 03	0.102211E+00
101	0.366097E 03	0.366912E 03	-0.222347E+02
102	0.405210E 03	0.372914E 03	0.797021E+01
103	0.393217E 03	0.384256E 03	0.227889E+01
104	0.413510E 03	0.388293E 03	0.605830E+01
105	0.385892E 03	0.392273E 03	-0.165335E+01
106	0.393285E 03	0.392387E 03	0.228265E+02
107	0.387072E 03	0.391654E 03	-0.118372E+01
108	0.380885E 03	0.386633E 03	-0.150915E+01
109	0.372235E 03	0.367318E 03	0.132092E+01
110	0.341600E 03	0.341173E 03	0.124852E+02
111	0.281290E 03	0.316427E 03	-0.124913E+00
112	0.254477E 03	0.283535E 03	-0.114185E+00
113	0.216585E 03	0.247701E 03	-0.143664E+00
114	0.170402E 03	0.220537E 03	-0.294211E+00
115	0.181697E 03	0.195830E 03	-0.777808E+01
116	0.155002E 03	0.165629E 03	-0.685555E+01
117	0.128575E 03	0.141204E 03	-0.982202E+01
118	0.968975E 02	0.123311E 03	-0.272590E+00
119	0.823800E 02	0.107344E 03	-0.303032E+00
120	0.837150E 02	0.944472E 02	-0.128159E+00
121	0.754375E 02	0.839179E 02	-0.112416E+00
122	0.757425E 02	0.740927E 02	0.217823E+01
123	0.751750E 02	0.667778E 02	0.111702E+00
124	0.654150E 02	0.605729E 02	0.740210E+01
125	0.583150E 02	0.598158E 02	-0.257365E+01
126	0.627025E 02	0.723394E 02	-0.193692E+00

127	0.102467E 03	0.947718E 02	0.7510408+01
128	0.151947E 03	0.141807E 03	0.6673908+01
129	0.214392E 03	0.213221E 03	0.5465498+02
130	0.340302E 03	0.329215E 03	0.3258168+01
131	0.559600E 03	0.493984E 03	0.1172548+00
132	0.781742E 03	0.729867E 03	0.6635918+01
133	0.100867E 04	0.996679E 03	0.1189298+01
134	0.139285E 04	0.131455E 04	0.5621558+01
135	0.159396E 04	0.158020E 04	0.8633628+02
136	0.178508E 04	0.176109E 04	0.1344248+01
137	0.187352E 04	0.183677E 04	0.1961448+01
138	0.177173E 04	0.176842E 04	0.1870118+02
139	0.158321E 04	0.158989E 04	-0.4217768+02
140	0.129145E 04	0.135621E 04	-0.5014158+01
141	0.105752E 04	0.108739E 04	-0.2825018+01
142	0.725605E 03	0.833040E 03	-0.1480628+00
143	0.496477E 03	0.599958E 03	-0.2084298+00
144	0.342562E 03	0.417821E 03	-0.2196938+00
145	0.211560E 03	0.289579E 03	-0.3687808+00
146	0.167185E 03	0.194346E 03	-0.1624598+00
147	0.970150E 02	0.134368E 03	-0.3850288+00
148	0.847775E 02	0.967625E 02	-0.1413708+00
149	0.355900E 02	0.662908E 02	-0.8626238 00
150	0.402275E 02	0.460753E 02	-0.1453678+00
151	0.314400E 02	0.362644E 02	-0.1534478+00
152	0.299100E 02	0.294707E 02	0.1468618+01
153	0.247875E 02	0.250137E 02	-0.9123988+02
154	0.214575E 02	0.214170E 02	0.1888508+02
155	0.226275E 02	0.186544E 02	0.1755888+00
156	0.155350E 02	0.171453E 02	-0.1036558+00
157	0.214575E 02	0.171239E 02	0.2019628+00
158	0.154150E 02	0.178615E 02	-0.1587098+00
159	0.128875E 02	0.174680E 02	-0.3554258+00
160	0.168850E 02	0.176670E 02	-0.4631218+01
161	0.228575E 02	0.190928E 02	0.1647018+00
162	0.116575E 02	0.159972E 02	-0.3722678+00
163	0.124600E 02	0.171607E 02	-0.3772628+00
164	0.210125E 02	0.167516E 02	0.2027788+00
165	0.970750E 01	0.176024E 02	-0.8132808 00
166	0.183525E 02	0.169069E 02	0.7876808+01
167	0.758750E 01	0.155616E 02	-0.1050958 01
168	0.983750E 01	0.161014E 02	-0.6367398 00
169	0.121900E 02	0.137348E 02	-0.1267288+00
170	0.113400E 02	0.125574E 02	-0.1073548+00
171	0.135125E 02	0.114609E 02	0.1518298+00
172	0.278500E 01	0.103059E 02	-0.2700508 01
173	0.166500E 01	0.942066E 01	-0.4658058 01
174	0.149200E 02	0.925994E 01	0.3793618+00
175	0.101950E 02	0.911401E 01	0.1060328+00
176	0.110400E 02	0.748679E 01	0.3218538+00
177	0.400500E 01	0.556011E 01	-0.3882928+00
178	0.111025E 02	0.538543E 01	0.5149358 00
179	0.600250E 01	0.521579E 01	0.1310638+00
180	0.800500E 01	0.429426E 01	0.4635538+00
181	0.469000E 01	0.615535E 01	-0.3124428+00
182	0.244000E 01	0.557548E 01	-0.1285038 01
183	0.650250E 01	0.458803E 01	0.2944218+00
184	0.795000E 01	0.524750E 01	0.3399378+00
185	0.135275E 02	0.747474E 01	0.4474418+00
186	0.133825E 02	0.956022E 01	0.2856188+00
187	0.735250E 01	0.121910E 02	-0.6580828 00
188	0.202775E 02	0.172134E 02	0.1511088+00
189	0.273400E 02	0.209948E 02	0.2320838+00
190	0.234600E 02	0.247648E 02	-0.5561648+01
191	0.408600E 02	0.305197E 02	0.2530678+00
192	0.361700E 02	0.335642E 02	0.7204298+01

193	0.315525E 02	0.357586E 02	+0.1333068+00
194	0.338600E 02	0.356175E 02	+0.5190498+01
195	0.291275E 02	0.312774E 02	+0.7381148+01
196	0.161350E 02	0.294494E 02	+0.8251908 00
197	0.202675E 02	0.218309E 02	+0.7713638+01
198	0.214475E 02	0.182456E 02	0.1492928+00
199	0.562000E 01	0.139324E 02	+0.1479078 01
200	0.685750E 01	0.112274E 02	+0.6372428 00
201	0.486000E 01	0.757231E 01	+0.5580898 00
202	0.609750E 01	0.552288E 01	0.9423838+01
203	0.623000E 01	0.455508E 01	0.2688478+00
204	0.247500E+00	0.338849E 01	+0.1269098 02

ZERO DRIFT OF -0.00781 GIVES CHI SQUARE VALUE 0.8082828 01

CORRELATION MATRIX STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
OFF DIAGONAL ELEMENT = CROSS CORRELATION

ROW 1

0.11454E-02

ROW 2

0.70115E-01 0.47273E-02

ROW 3

0.48517E-02 0.14741E-02 0.27569E-02

COMPONENT NA 22

0.	8706.20	17747.86	20574.09	20446.52	19934.22	19167.88
18697.75	19316.13	20164.99	20009.32	18989.71	17970.52	17659.19
17539.95	17312.02	17005.35	16786.94	16587.78	16271.60	16111.97
15946.44	15890.77	16039.37	16291.83	16242.49	15810.51	14743.96
13085.26	11274.78	9528.42	8200.96	7237.25	6620.65	6216.96
5952.91	5616.99	5410.50	5236.32	5120.50	4989.14	4996.77
5187.94	5618.70	7061.74	11307.52	20727.22	37545.63	62108.13
90118.34	112203.57	118585.27	105693.18	78781.04	49840.96	28294.06
15363.22	8586.52	5427.18	4018.41	3339.18	3012.43	2875.39
2846.65	2798.10	2720.75	2703.03	2695.45	2731.43	2739.97
2742.77	2736.38	2753.71	2731.30	2803.32	2807.85	2855.36
2851.33	2883.97	2933.74	2995.23	3007.38	2999.82	3022.93
2999.13	2937.50	2972.12	3047.81	3038.47	3062.98	3126.70
3208.75	3199.43	3285.95	3363.38	3396.99	3412.65	3439.72
3455.41	3565.94	3652.74	3712.49	3825.41	3865.60	3905.22
3906.36	3899.06	3849.07	3656.78	3396.50	3150.14	2822.69
2465.95	2195.52	1949.56	1648.89	1405.73	1227.60	1068.65
940.26	835.43	737.62	664.80	603.03	595.49	720.16
943.49	1411.74	2122.69	3277.45	4917.79	7266.09	9922.30
13086.84	15731.44	17532.25	18285.70	17605.22	15827.95	13501.51
10825.38	8293.21	5972.80	4159.56	2882.86	1934.78	1337.69
963.31	659.95	458.70	361.02	293.39	249.02	213.21
185.71	170.69	170.47	177.82	173.90	175.88	198.08
159.26	170.84	166.77	175.24	168.31	154.92	160.30
136.74	125.01	114.10	102.60	93.79	92.19	90.73
74.53	55.35	53.61	51.93	42.75	61.28	55.51
45.68	52.24	74.41	95.18	121.37	171.37	209.01
246.54	303.83	334.14	355.99	354.58	311.38	293.18
217.33	181.64	138.70	111.77	75.39	54.98	45.35
33.73	21.94	13.37	4.39	0.41	+0.	+0.
-0.	-0.	-0.	+0.	-0.	+0.	+0.
-0.	+0.	-0.	+0.	-0.	+0.	+0.
-0.	-0.	-0.	+0.	-0.	+0.	+0.
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-0.	+0.	-0.	+0.	-0.	+0.	+0.

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   -0.      +0.      +0.      +0.      -0.      +0.      +0.
   -0.      +0.      +0.

   COMPONENT C6137
   94.70   1278.48  3548.12  3509.49  3491.96  3516.96  3133.44
 3123.82   3055.89  3031.90  3250.41  3437.70  3541.58  3376.03
 3144.67   2977.82  2934.66  2993.82  2887.90  2858.05  2775.96
 2784.09   2840.40  2814.23  2631.99  2606.42  2548.57  2573.35
 2461.35   2509.70  2387.64  2359.67  2331.72  2331.02  2359.75
 2487.67   2516.26  2619.32  2551.34  2583.45  2625.35  2639.56
 2538.04   2378.78  2077.64  1733.75  1384.88  1145.14   904.40
  738.98    624.00   545.15   477.09   426.33   409.82   389.63
  352.73    334.10   377.92   371.79   468.33   833.57  1391.35
 2762.20   5321.81  9071.16 13687.98 18348.67 21233.71 21493.26
18368.96  13600.80  8702.18  4802.22  2590.51  1263.48   536.54
  228.03    117.35    61.93    16.55     1.39     +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      +0.      +0.      -0.      +0.      +0.
   -0.      -0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      +0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      +0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -0.      +0.      -0.      +0.      +0.
   -0.      +0.      -
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-0.	+0.	-0.	+0.	-0.	+0.	+0.
-0.	+0.	-0.	+0.	-0.	+0.	+0.
-0.	+0.	-0.				

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INPUT CORRECTED LIBRARY DATA INTO FLOW 2

PROBLEM 2

292-232 O—68——11

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LIBRARY   GAMT1  255    3    1
NA 22
      0.     8706.20   17747.86   20574.09   20446.52   19934.22   19167.88
  18697.75   19316.13   20164.99   20009.32   18989.71   17970.52   17659.19
  17539.95   17312.02   17005.35   16786.94   16587.78   16271.60   16111.97
  15946.44   15890.77   16039.37   16291.83   16242.49   15810.51   14743.96
  13085.26   11274.78    9528.42    8200.96    7237.25    6620.65    6216.96
   5952.91    5616.99    5410.50    5236.32    5120.50    4989.14    4996.77
   5187.94    5618.70    7061.74   11307.52   20727.22   37545.63   62108.13
  90118.34  112203.57  118585.27  105693.18   78781.04   49840.96   28294.06
  15363.22    8586.52    5427.18    4018.41    3339.18    3012.43    2875.39
   2846.65    2798.10    2720.75    2703.03    2695.45    2731.43    2739.97
   2742.77    2736.38    2753.71    2731.30    2803.32    2807.85    2855.36
   2851.33    2883.97    2933.74    2995.23    3007.38    2999.82    3022.93
   2999.13    2937.50    2972.12    3047.81    3038.47    3062.98    3126.70
   3208.75    3199.43    3285.95    3363.38    3396.99    3412.65    3439.72
   3455.41    3565.94    3652.74    3712.49    3825.41    3865.60    3905.22
   3906.36    3899.06    3849.07    3656.78    3396.50    3150.14    2822.69
   2465.95    2195.52    1949.56    1648.89    1405.73    1227.60    1068.65
    940.26     835.43     737.62     664.80     603.03     595.49     720.16
    943.49    1411.74    2122.69    3277.45    4917.79    7266.09    9922.30
  13086.84   15731.44   17532.25   18285.70   17605.22   15827.95   13501.51
  10825.38    8293.21    5972.80    4159.56    2882.86    1934.78    1337.69
    963.31     659.95     458.70     361.02     293.39     249.02     213.21
    185.71     170.69     170.47     177.82     173.90     175.88     190.08
    159.26     170.84     166.77     175.24     168.31     154.92     160.30
    136.74     125.01     114.10     102.60      93.79      92.19      90.73
     74.53      55.35      53.61      51.93      42.75      61.28      55.51
     45.68      52.24      74.41      95.18     121.37     171.37     209.01
    246.54     303.83     334.14     355.99     354.58     311.38     293.18
    217.33     181.64     138.70     111.77      75.39      54.98      45.35
     33.73      21.94      13.37       4.39       0.41       -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.
CS137
     94.70    1278.48    3548.12    3509.49    3491.96    3516.96    3133.44
   3123.82    3055.89    3031.90    3250.41    3437.70    3541.58    3376.03
   3144.67    2977.82    2934.66    2993.82    2887.90    2858.05    2775.96
   2784.09    2840.40    2814.23    2631.99    2606.42    2548.57    2573.35
   2461.35    2509.70    2387.64    2359.67    2331.72    2331.02    2359.75
   2487.67    2516.26    2619.32    2551.34    2583.45    2625.35    2639.56
   2538.04    2378.78    2077.64    1733.75    1384.88    1145.14     904.40
    738.98     624.00     545.15     477.09     426.33     409.82     389.63
    352.73     334.10     377.92     371.79     468.33     833.57    1391.35
   2762.20    5321.81    9071.16   13687.98   18348.67   21233.71   21493.26
  18368.96   13600.80    8702.18    4802.22    2590.51    1263.48     536.54
    228.03     117.35      61.93      16.55       1.39       -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
      -0.        -0.        -0.        -0.        -0.        -0.        -0.
```

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      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.
CO 57
     33.57   4447.53  23637.00  31986.22 120312.84 228061.96  75358.43
  14741.90   1745.84    166.27     15.38      -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       -0.       -0.       -0.
      -0.       -0.       -0.       -0.       
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RESULTS OF FLOW 2 CORRECTED LIBRARY
PROBLEM 2

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LINEAR LEAST SQUARES ANALYSIS OF RADIATION SPECTRA
FUNCTION LIBRARY  GAMT1    OF   3  ELEMENTS AND  255  CHANNELS,STARTING WITH CHANNEL,   1
SPECTRUM TC BE ANALYZEC  GAMMA9  OF 255  CHANNELS,STARTING WITH CHANNEL,   1


FLOW OPTION  2     ITERATIVE MODE
NO GAIN SHIFT OF BACKGROUND
SPECTRUM GAIN SEARCH FROM       0.90 TO       1.10
GAIN SHIFT OF   0.90000   GIVES CHI SQUARE VALUE   0.843647E 03
GAIN SHIFT OF   1.10000   GIVES CHI SQUARE VALUE   0.714181E 03
GAIN SHIFT OF   1.00000   GIVES CHI SQUARE VALUE   0.313911E 01
GAIN SHIFT OF   0.95000   GIVES CHI SQUARE VALUE   0.454609E 03
GAIN SHIFT OF   1.05000   GIVES CHI SQUARE VALUE   0.397114E 03
GAIN SHIFT OF   0.97500   GIVES CHI SQUARE VALUE   0.147250E 03
GAIN SHIFT OF   1.02500   GIVES CHI SQUARE VALUE   0.136528E 03
GAIN SHIFT OF   0.98750   GIVES CHI SQUARE VALUE   0.401920E 02
GAIN SHIFT OF   1.01250   GIVES CHI SQUARE VALUE   0.390588E 02
GAIN SHIFT OF   0.99375   GIVES CHI SQUARE VALUE   0.116309E 02
GAIN SHIFT OF   1.00625   GIVES CHI SQUARE VALUE   0.120226E 02
GAIN SHIFT OF   0.99687   GIVES CHI SQUARE VALUE   0.464527E 01
USING FUNCTIONAL LIBRARY FROM CHANNEL   3   THROUGH  255
AND USING ELEMENTS    NA 22 CS137 CO 57
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RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
NA 22	0.100353E-00
CS137	0.201346E-00
CO 57	0.193128E-00

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
3	0.782490E 04	0.706043E 04	0.976968E-01
4	0.886311E 04	0.894874E 04	-0.966167E-02
5	0.245282E 05	0.259908E 05	-0.596274E-01
6	0.475905E 05	0.467538E 05	0.175809E-01
7	0.172501E 05	0.171083E 05	0.821852E-02
8	0.558115E 04	0.535243E 04	0.409809E-01
9	0.308647E 04	0.289090E 04	0.633630E-01
10	0.271852E 04	0.266620E 04	0.192452E-01
11	0.279237E 04	0.266543E 04	0.454576E-01
12	0.272599E 04	0.259785E 04	0.470066E-01
13	0.250603E 04	0.251649E 04	-0.417465E-02
14	0.238502E 04	0.245191E 04	-0.280487E-01
15	0.237000E 04	0.239336E 04	-0.985586E-02
16	0.243238E 04	0.233689E 04	0.392578E-01
17	0.230257E 04	0.229743E 04	0.223097E-02
18	0.227555E 04	0.228742E 04	-0.521793E-02
19	0.231092E 04	0.224611E 04	0.280440E-01
20	0.233181E 04	0.220837E 04	0.529376E-01
21	0.225309E 04	0.217582E 04	0.342940E-01
22	0.226240E 04	0.216085E 04	0.448895E-01
23	0.216493E 04	0.216660E 04	-0.768305E-03
24	0.217494E 04	0.217624E 04	-0.596027E-03
25	0.214053E 04	0.216488E 04	-0.113763E-01
26	0.218403E 04	0.215478E 04	0.133920E-01
27	0.210177E 04	0.209978E 04	0.945959E-03
28	0.205008E 04	0.199774E 04	0.255305E-01
29	0.190195E 04	0.180873E 04	0.490084E-01
30	0.167537E 04	0.163678E 04	0.230303E-01
31	0.156232E 04	0.143695E 04	0.802423E-01
32	0.135369E 04	0.129811E 04	0.410622E-01
33	0.130333E 04	0.119577E 04	0.825283E-01
34	0.117385E 04	0.113375E 04	0.341623E-01
35	0.120844E 04	0.109902E 04	0.905477E-01
36	0.109496E 04	0.109828E 04	-0.302824E-02
37	0.110837E 04	0.107032E 04	0.343253E-01
38	0.102256E 04	0.107035E 04	-0.467407E-01
39	0.102696E 04	0.103919E 04	-0.119004E-01
40	0.101115E 04	0.103403E 04	-0.226263E-01
41	0.106770E 04	0.102928E 04	0.359826E-01
42	0.107617E 04	0.103291E 04	0.401960E-01
43	0.100987E 04	0.103165E 04	-0.215741E-01
44	0.107055E 04	0.104281E 04	0.259098E-01
45	0.105973E 04	0.112699E 04	-0.634695E-01
46	0.129350E 04	0.148383E 04	-0.147143E-00
47	0.196714E 04	0.235889E 04	-0.199144E-00
48	0.345884E 04	0.399840E 04	-0.155994E-00
49	0.573538E 04	0.641487E 04	-0.118472E-00
50	0.886775E 04	0.919248E 04	-0.366192E-01
51	0.113544E 05	0.113857E 05	-0.275480E-02
52	0.122051E 05	0.120102E 05	0.159703E-01
53	0.111019E 05	0.107027E 05	0.359580E-01
54	0.841578E 04	0.799179E 04	0.503806E-01
55	0.543666E 04	0.508423E 04	0.648239E-01
56	0.311429E 04	0.291786E 04	0.630748E-01
57	0.160963E 04	0.161277E 04	-0.195318E-02
58	0.965246E 03	0.928957E 03	0.375958E-01
59	0.600604E 03	0.620729E 03	-0.335084E-01
60	0.495229E 03	0.478120E 03	0.345478E-01
61	0.434656E 03	0.429395E 03	0.121043E-01

62	0.445643E 03	0.470144E 03	-0.549783E-01
63	0.550273E 03	0.568698E 03	-0.334846E-01
64	0.765754E 03	0.841829E 03	-0.993463E-01
65	0.128597E 04	0.135232E 04	-0.515983E-01
66	0.203603E 04	0.209948E 04	-0.311645E-01
67	0.296080E 04	0.302728E 04	-0.224539E-01
68	0.385403E 04	0.396493E 04	-0.287750E-01
69	0.442155E 04	0.454943E 04	-0.289228E-01
70	0.450938E 04	0.460255E 04	-0.206609E-01
71	0.395037E 04	0.397376E 04	-0.592178E-02
72	0.304348E 04	0.301307E 04	0.999227E-02
73	0.213424E 04	0.202849E 04	0.495480E-01
74	0.138777E 04	0.124100E 04	0.105756E-00
75	0.922558E 03	0.802912E 03	0.129689E-00
76	0.590473E 03	0.536174E 03	0.919575E-01
77	0.438103E 03	0.394576E 03	0.993535E-01
78	0.379233E 03	0.332054E 03	0.124407E-00
79	0.336439E 03	0.313044E 03	0.695349E-01
80	0.332654E 03	0.306880E 03	0.774797E-01
81	0.350649E 03	0.303914E 03	0.133282E-00
82	0.316414E 03	0.302081E 03	0.452972E-01
83	0.346780E 03	0.301042E 03	0.131892E-00
84	0.328625E 03	0.303362E 03	0.768760E-01
85	0.305865E 03	0.300973E 03	0.159933E-01
86	0.304976E 03	0.294788E 03	0.334056E-01
87	0.293976E 03	0.298263E 03	-0.145825E-01
88	0.301250E 03	0.305858E 03	-0.152983E-01
89	0.301901E 03	0.304921E 03	-0.100047E-01
90	0.302643E 03	0.307381E 03	-0.156553E-01
91	0.304655E 03	0.313775E 03	-0.299375E-01
92	0.302133E 03	0.322009E 03	-0.657848E-01
93	0.317909E 03	0.321074E 03	-0.995509E-02
94	0.345248E 03	0.329757E 03	0.448696E-01
95	0.348198E 03	0.337527E 03	0.306472E-01
96	0.339261E 03	0.340900E 03	-0.483009E-02
97	0.359270E 03	0.342471E 03	0.467568E-01
98	0.348106E 03	0.345188E 03	0.838231E-02
99	0.350042E 03	0.346762E 03	0.936919E-02
100	0.390852E 03	0.357855E 03	0.844237E-01
101	0.370696E 03	0.366565E 03	0.111437E-01
102	0.398360E 03	0.372561E 03	0.647627E-01
103	0.394670E 03	0.383893E 03	0.273051E-01
104	0.409606E 03	0.387926E 03	0.529269E-01
105	0.389851E 03	0.391902E 03	-0.526229E-02
106	0.391497E 03	0.392017E 03	-0.132678E-02
107	0.387618E 03	0.391284E 03	-0.945790E-02
108	0.381453E 03	0.386268E 03	-0.126229E-01
109	0.373167E 03	0.366971E 03	0.166049E-01
110	0.346364E 03	0.340851E 03	0.159173E-01
111	0.291384E 03	0.316128E 03	-0.849169E-01
112	0.258777E 03	0.283267E 03	-0.946351E-01
113	0.222922E 03	0.247467E 03	-0.110103E-00
114	0.178291E 03	0.220328E 03	-0.235776E-00
115	0.179431E 03	0.195645E 03	-0.903660E-01
116	0.159444E 03	0.165472E 03	-0.378031E-01
117	0.133098E 03	0.141070E 03	-0.598956E-01
118	0.102428E 03	0.123194E 03	-0.202734E-00
119	0.848299E 02	0.107243E 03	-0.264210E-00
120	0.831930E 02	0.943584E 02	-0.134211E-00
121	0.768095E 02	0.838383E 02	-0.915092E-01
122	0.756068E 02	0.740227E 02	0.209509E-01
123	0.752324E 02	0.667150E 02	0.113215E-00
124	0.672279E 02	0.605162E 02	0.998351E-01
125	0.597665E 02	0.597595E 02	0.117393E-03
126	0.618051E 02	0.722706E 02	-0.169329E-00
127	0.945795E 02	0.946825E 02	-0.108894E-02

128	0.141929E 03	0.141673E 03	0.180077E-02
129	0.201588E 03	0.213019E 03	-0.567042E-01
130	0.314246E 03	0.328904E 03	-0.466433E-01
131	0.514029E 03	0.493517E 03	0.399045E-01
132	0.734868E 03	0.729178E 03	0.774328E-02
133	0.960065E 03	0.995737E 03	-0.371567E-01
134	0.131052E 04	0.131331E 04	-0.212827E-02
135	0.154920E 04	0.157870E 04	-0.190474E-01
136	0.174183E 04	0.175942E 04	-0.101020E-01
137	0.185181E 04	0.183503E 04	0.905728E-02
138	0.179088E 04	0.176675E 04	0.134770E-01
139	0.162166E 04	0.158839E 04	0.205133E-01
140	0.135310E 04	0.135492E 04	-0.134670E-02
141	0.110725E 04	0.108636E 04	0.188629E-01
142	0.797896E 03	0.832253E 03	-0.430589E-01
143	0.546701E 03	0.599391E 03	-0.963788E-01
144	0.376561E 03	0.417426E 03	-0.108523E-00
145	0.240808E 03	0.289305E 03	-0.201392E-00
146	0.176921E 03	0.194162E 03	-0.974490E-01
147	0.112882E 03	0.134242E 03	-0.189223E-00
148	0.874018E 02	0.966715E 02	-0.106058E-00
149	0.468965E 02	0.662283E 02	-0.412223E-00
150	0.389860E 02	0.460321E 02	-0.180736E-00
151	0.332607E 02	0.362296E 02	-0.892606E-01
152	0.300875E 02	0.294427E 02	0.214296E-01
153	0.259276E 02	0.249900E 02	0.361605E-01
154	0.218889E 02	0.213964E 02	0.225005E-01
155	0.220932E 02	0.186366E 02	0.156452E-00
156	0.171953E 02	0.171293E 02	0.383852E-02
157	0.199403E 02	0.171073E 02	0.142077E-00
158	0.168510E 02	0.178449E 02	-0.589764E-01
159	0.135946E 02	0.174515E 02	-0.283707E-00
160	0.160968E 02	0.176502E 02	-0.965024E-01
161	0.215553E 02	0.190752E 02	0.115057E-00
162	0.146558E 02	0.159823E 02	-0.905072E-01
163	0.124304E 02	0.171444E 02	-0.379235E-00
164	0.189268E 02	0.167360E 02	0.115754E-00
165	0.127681E 02	0.175859E 02	-0.377330E-00
166	0.162481E 02	0.168905E 02	-0.395346E-01
167	0.104301E 02	0.155468E 02	-0.490567E-00
168	0.929231E 01	0.160867E 02	-0.731181E 00
169	0.116386E 02	0.137223E 02	-0.179040E-00
170	0.115814E 02	0.125452E 02	-0.832197E-01
171	0.129533E 02	0.114503E 02	0.116028E-00
172	0.572263E 01	0.102963E 02	-0.799221E 00
173	0.192666E 01	0.941215E 01	-0.388521E 01
174	0.113686E 02	0.925159E 01	0.186218E-00
175	0.115376E 02	0.910507E 01	0.210836E-00
176	0.107440E 02	0.747935E 01	0.303860E-00
177	0.592395E 01	0.555457E 01	0.623547E-01
178	0.913989E 01	0.537995E 01	0.411377E-00
179	0.738251E 01	0.521136E 01	0.294094E-00
180	0.742710E 01	0.429011E 01	0.422371E-00
181	0.552329E 01	0.614966E 01	-0.113405E-00
182	0.299760E 01	0.557062E 01	-0.858358E 00
183	0.534673E 01	0.458415E 01	0.142627E-00
184	0.735808E 01	0.524247E 01	0.287523E-00
185	0.117705E 02	0.746730E 01	0.365591E-00
186	0.133544E 02	0.955165E 01	0.284758E-00
187	0.908140E 01	0.121799E 02	-0.341192E-00
188	0.164317E 02	0.171976E 02	-0.466089E-01
189	0.252294E 02	0.209749E 02	0.168632E-00
190	0.246001E 02	0.247411E 02	-0.573393E-02
191	0.357323E 02	0.304904E 02	0.146699E-00
192	0.376029E 02	0.335321E 02	0.108257E-00
193	0.330010E 02	0.357248E 02	-0.825385E-01

194	0.331979E 02	0.355833E 02	-0.718543E-01
195	0.305962E 02	0.312481E 02	-0.213043E-01
196	0.200741E 02	0.294216E 02	-0.465650E-00
197	0.190042E 02	0.218098E 02	-0.147630E-00
198	0.211017E 02	0.182282E 02	0.136172E-00
199	0.105669E 02	0.139190E 02	-0.317225E-00
200	0.653194E 01	0.112165E 02	-0.717179E 00
201	0.547523E 01	0.756565E 01	-0.381795E-00
202	0.577038E 01	0.551743E 01	0.438359E-01
203	0.621752E 01	0.455103E 01	0.268031E-00
204	0.215089E 01	0.338492E 01	-0.573733E 00
205	0.241177E 01	0.220176E 01	0.870805E-01
206	0.6944C3E 0C	0.134173E 01	-0.932201E 00
207	C.141899E 01	0.440552E-00	0.689532E 00
208	0.114234E 01	0.411449E-01	0.963982E 00
209	0.109728E 01	-0.	0.100000E 01
210	0.893977E CC	-0.	0.100000E 01
211	-0.979061E-01	-0.	0.100000E 01
212	0.232386E 01	-0.	0.100000E 01
213	0.229136E 01	-0.	0.100000E 01
214	0.154032E 01	-0.	0.100000E 01
215	0.839265E CC	-0.	0.100000E 01
216	-0.947116E 00	-0.	0.100000E 01
217	-0.251619E-00	-0.	0.100000E 01
218	-0.269503E-00	-0.	0.100000E 01
219	-0.417339E-01	-0.	0.100000E 01
220	0.149841E 01	-0.	0.100000E 01
221	0.145205E 01	-0.	0.100000E 01
222	-0.312485E-0C	-0.	0.100000E 01
223	-0.999060E 00	-0.	0.100000E 01
224	0.252516E-00	-0.	0.100000E 01
225	0.429841E-00	-0.	0.100000E 01
226	0.6358C2E 00	-0.	0.100000E 01
227	0.327956E-00	-0.	0.100000E 01
228	-0.591427E 00	-0.	0.100000E 01
229	0.131940E-00	-0.	0.100000E 01
230	-0.405065E-0C	-0.	0.100000E 01
231	0.801840E 00	-0.	0.100000E 01
232	0.662107E 00	-0.	0.100000E 01
233	0.152042E 01	-0.	0.100000E 01
234	-0.369587E-00	-0.	0.100000E 01
235	-0.525191E 00	-0.	0.100000E 01
236	-0.403965E-0C	-0.	0.100000E 01
237	-0.197720E-C1	-0.	0.100000E 01
238	0.369380E-0C	-0.	0.100000E 01
239	-0.717967E 00	-0.	0.100000E 01
240	0.566349E 00	-0.	0.100000E 01
241	0.471706E-0C	-0.	0.100000E 01
242	-0.848060E 00	-0.	0.100000E 01
243	0.679828E 00	-0.	0.100000E 01
244	0.508549E 00	-0.	0.100000E 01
245	-0.4906C0E-01	-0.	0.100000E 01
246	-0.131560E-00	-0.	0.100000E 01
247	0.579652E 00	-0.	0.100000E 01
248	C.979380E 0C	-0.	0.100000E 01
249	0.173248E 01	-0.	0.100000E 01
250	0.2357C0E-00	-0.	0.100000E 01
251	-0.960000E 00	-0.	0.100000E 01
252	0.404347E-00	-0.	0.100000E 01
253	-0.129353E-00	-0.	0.100000E 01
254	-0.850000E 0C	-0.	0.100000E 01
255	0.337504E-00	-0.	0.100000E 01

GAIN SHIFT OF 1.00156 GIVES CHI SQUARE VALUE 0.328980E 01

SPECTRUM ZERO SEARCH FROM -5.00 TO 5.00

ZERO DRIFT OF -5.00000 GIVES CHI SQUARE VALUE 0.532480E 03
ZERO DRIFT OF 5.00000 GIVES CHI SQUARE VALUE 0.970445E 03
ZERO DRIFT OF 0. GIVES CHI SQUARE VALUE 0.328980E 01
ZERO DRIFT OF -2.50000 GIVES CHI SQUARE VALUE 0.470889E 03
ZERO DRIFT OF 2.50000 GIVES CHI SQUARE VALUE 0.581893E 03
ZERO DRIFT OF -1.25000 GIVES CHI SQUARE VALUE 0.257361E 03
ZERO DRIFT OF 1.25000 GIVES CHI SQUARE VALUE 0.293086E 03
ZERO DRIFT OF -0.62500 GIVES CHI SQUARE VALUE 0.883690E 02
ZERO DRIFT OF 0.62500 GIVES CHI SQUARE VALUE 0.117967E 03
ZERO DRIFT OF -0.31250 GIVES CHI SQUARE VALUE 0.224161E 02
ZERO DRIFT OF 0.31250 GIVES CHI SQUARE VALUE 0.407105E 02
ZERO DRIFT OF -0.15625 GIVES CHI SQUARE VALUE 0.594634E 01
ZERO DRIFT OF 0.15625 GIVES CHI SQUARE VALUE 0.152962E 02
ZERO DRIFT OF -0.07813 GIVES CHI SQUARE VALUE 0.270571E 01
ZERO DRIFT OF -0.03906 GIVES CHI SQUARE VALUE 0.249506E 01
ZERO DRIFT OF -0.05859 GIVES CHI SQUARE VALUE 0.247709E 01
ZERO DRIFT OF -0.04883 GIVES CHI SQUARE VALUE 0.245477E 01
ZERO DRIFT OF -0.05371 GIVES CHI SQUARE VALUE 0.245817E 01
ZERO DRIFT OF -0.04395 GIVES CHI SQUARE VALUE 0.246703E 01
USING FUNCTIONAL LIBRARY FROM CHANNEL 3 THROUGH 254
AND USING ELEMENTS NA 22 CS137 CO 57

RELATIVE INTENSITY VECTOR

ELEMENT	INTENSITY
NA 22	0.100441E-00
CS137	0.201573E-00
CO 57	0.192159E-00

FINAL TABULATED RESULTS SHOWING GIVEN AND THEORETICAL SPECTRA AND THEIR DIFFERENCES

CHANNEL	ACTUAL SPECTRUM	CALCULATED SPECTRUM	DIFFERENCE(P.C.) ACTUAL-CALCULATED
3	0.787575E 04	0.703989E 04	0.106130E-00
4	0.962605E 04	0.892036E 04	0.733110E-01
5	0.256527E 05	0.258768E 05	-0.873547E-02
6	0.461062E 05	0.465353E 05	-0.930809E-02
7	0.166777E 05	0.170377E 05	-0.215842E-01
8	0.545703E 04	0.534050E 04	0.213546E-01
9	0.306676E 04	0.289161E 04	0.571134E-01
10	0.272072E 04	0.266850E 04	0.191940E-01
11	0.278810E 04	0.266792E 04	0.431073E-01
12	0.271416E 04	0.260030E 04	0.419486E-01
13	0.249901E 04	0.251887E 04	-0.794837E-02
14	0.238334E 04	0.245423E 04	-0.297451E-01
15	0.237244E 04	0.239562E 04	-0.977115E-02
16	0.242580E 04	0.233909E 04	0.357443E-01
17	0.230120E 04	0.229959E 04	0.698687E-03
18	0.227689E 04	0.228958E 04	-0.557505E-02
19	0.231101E 04	0.224823E 04	0.271658E-01
20	0.232700E 04	0.221045E 04	0.500862E-01
21	0.225278E 04	0.217787E 04	0.332542E-01
22	0.225728E 04	0.216288E 04	0.418175E-01
23	0.216531E 04	0.216864E 04	-0.154015E-02
24	0.217323E 04	0.217829E 04	-0.232789E-02
25	0.214238E 04	0.216691E 04	-0.114526E-01
26	0.217958E 04	0.215680E 04	0.104506E-01
27	0.209873E 04	0.210175E 04	-0.144162E-02
28	0.204255E 04	0.199962E 04	0.210161E-01
29	0.189086E 04	0.181045E 04	0.425283E-01
30	0.167006E 04	0.163834E 04	0.189909E-01
31	0.155239E 04	0.143833E 04	0.734732E-01
32	0.135105E 04	0.129936E 04	0.382602E-01
33	0.129656E 04	0.119693E 04	0.768423E-01
34	0.117490E 04	0.113486E 04	0.340838E-01
35	0.120236E 04	0.110010E 04	0.850451E-01
36	0.109519E 04	0.109937E 04	-0.381208E-02
37	0.110400E 04	0.107139E 04	0.295403E-01
38	0.102260E 04	0.107142E 04	-0.477446E-01
39	0.102607E 04	0.104023E 04	-0.137959E-01
40	0.101383E 04	0.103507E 04	-0.209497E-01
41	0.106802E 04	0.103032E 04	0.353049E-01
42	0.107286E 04	0.103395E 04	0.362650E-01
43	0.101280E 04	0.103269E 04	-0.196295E-01
44	0.106997E 04	0.104385E 04	0.244126E-01
45	0.107112E 04	0.112809E 04	-0.531845E-01
46	0.132633E 04	0.148522E 04	-0.119800E-00
47	0.203998E 04	0.236103E 04	-0.157375E-00
48	0.356998E 04	0.400197E 04	-0.121004E-00
49	0.588835E 04	0.642054E 04	-0.903791E-01
50	0.898922E 04	0.920058E 04	-0.235124E-01
51	0.113959E 05	0.113957E 05	0.198703E-04
52	0.121512E 05	0.120208E 05	0.107313E-01
53	0.109707E 05	0.107121E 05	0.235677E-01
54	0.827016E 04	0.799882E 04	0.328099E-01
55	0.532321E 04	0.508871E 04	0.440529E-01
56	0.304076E 04	0.292044E 04	0.395718E-01
57	0.157821E 04	0.161421E 04	-0.228077E-01
58	0.947558E 03	0.929788E 03	0.187528E-01
59	0.595618E 03	0.621293E 03	-0.431057E-01
60	0.492447E 03	0.478558E 03	0.282037E-01
61	0.435414E 03	0.429795E 03	0.129040E-01

62	0.450807E 03	0.470598E 03	-0.439021E-01
63	0.560785E 03	0.569268E 03	-0.151256E-01
64	0.790998E 03	0.842708E 03	-0.653733E-01
65	0.132232E 04	0.135378E 04	-0.237886E-01
66	0.208092E 04	0.210178E 04	-0.100229E-01
67	0.300424E 04	0.303063E 04	-0.878300E-02
68	0.388159E 04	0.396934E 04	-0.226071E-01
69	0.442575E 04	0.455450E 04	-0.290907E-01
70	0.448198E 04	0.460768E 04	-0.280440E-01
71	0.390604E 04	0.397818E 04	-0.184693E-01
72	0.299900E 04	0.301641E 04	-0.580491E-02
73	0.209775E 04	0.203072E 04	0.319564E-01
74	0.136503E 04	0.124234E 04	0.898810E-01
75	0.906337E 03	0.803748E 03	0.113191E-00
76	0.583004E 03	0.536709E 03	0.794078E-01
77	0.435237E 03	0.394949E 03	0.925667E-01
78	0.377147E 03	0.332357E 03	0.118762E-00
79	0.336229E 03	0.313325E 03	0.681206E-01
80	0.333555E 03	0.307153E 03	0.791542E-01
81	0.348993E 03	0.304181E 03	0.128403E-00
82	0.317892E 03	0.302346E 03	0.489029E-01
83	0.345852E 03	0.301306E 03	0.128801E-00
84	0.327473E 03	0.303628E 03	0.728178E-01
85	0.305801E 03	0.301237E 03	0.149236E-01
86	0.304399E 03	0.295047E 03	0.307250E-01
87	0.294304E 03	0.298524E 03	-0.143405E-01
88	0.301275E 03	0.306127E 03	-0.161043E-01
89	0.301936E 03	0.305188E 03	-0.107726E-01
90	0.302691E 03	0.307650E 03	-0.163823E-01
91	0.304536E 03	0.314050E 03	-0.312411E-01
92	0.302904E 03	0.322292E 03	-0.640044E-01
93	0.319250E 03	0.321355E 03	-0.659496E-02
94	0.345413E 03	0.330046E 03	0.444911E-01
95	0.347776E 03	0.337823E 03	0.286208E-01
96	0.340223E 03	0.341199E 03	-0.286927E-02
97	0.358752E 03	0.342772E 03	0.445445E-01
98	0.348185E 03	0.345491E 03	0.773926E-02
99	0.352055E 03	0.347066E 03	0.141690E-01
100	0.389861E 03	0.358168E 03	0.812934E-01
101	0.372041E 03	0.366887E 03	0.138556E-01
102	0.398131E 03	0.372888E 03	0.634034E-01
103	0.395385E 03	0.384230E 03	0.282128E-01
104	0.408622E 03	0.388267E 03	0.498156E-01
105	0.389912E 03	0.392246E 03	-0.598565E-02
106	0.391270E 03	0.392361E 03	-0.278835E-02
107	0.387278E 03	0.391627E 03	-0.112318E-01
108	0.381031E 03	0.386606E 03	-0.146323E-01
109	0.371840E 03	0.367292E 03	0.122313E-01
110	0.343646E 03	0.341149E 03	0.726358E-02
111	0.289783E 03	0.316405E 03	-0.918684E-01
112	0.257021E 03	0.283515E 03	-0.103080E-00
113	0.220752E 03	0.247684E 03	-0.122000E-00
114	0.178333E 03	0.220521E 03	-0.236573E-00
115	0.178489E 03	0.195817E 03	-0.970813E-01
116	0.158179E 03	0.165617E 03	-0.470236E-01
117	0.131633E 03	0.141194E 03	-0.726269E-01
118	0.101594E 03	0.123302E 03	-0.213671E-00
119	0.847824E 02	0.107337E 03	-0.266026E-00
120	0.828948E 02	0.944411E 02	-0.139288E-00
121	0.767359E 02	0.839118E 02	-0.935143E-01
122	0.755674E 02	0.740876E 02	0.195817E-01
123	0.748259E 02	0.667735E 02	0.107662E-00
124	0.668196E 02	0.605692E 02	0.935410E-01
125	0.598471E 02	0.598119E 02	0.588892E-03
126	0.633681E 02	0.723339E 02	-0.141488E-00
127	0.968681E 02	0.947655E 02	0.217051E-01

128	0.144820E 03	0.141797E 03	0.208722E-01
129	0.207094E 03	0.213206E 03	-0.295152E-01
130	0.323987E 03	0.329192E 03	-0.160665E-01
131	0.524806E 03	0.493950E 03	0.587942E-01
132	0.745867E 03	0.729817E 03	0.215189E-01
133	0.977168E 03	0.996610E 03	-0.198966E-01
134	0.132217E 04	0.131446E 04	0.583001E-02
135	0.155860E 04	0.158009E 04	-0.137897E-01
136	0.174718E 04	0.176097E 04	-0.789251E-02
137	0.184882E 04	0.183664E 04	0.658702E-02
138	0.178259E 04	0.176829E 04	0.802201E-02
139	0.160853E 04	0.158978E 04	0.116556E-01
140	0.134109E 04	0.135611E 04	-0.111982E-01
141	0.109214E 04	0.108732E 04	0.441703E-02
142	0.785637E 03	0.832982E 03	-0.602637E-01
143	0.538389E 03	0.599917E 03	-0.114281E-00
144	0.369932E 03	0.417792E 03	-0.129375E-00
145	0.237707E 03	0.289559E 03	-0.218133E-00
146	0.173803E 03	0.194332E 03	-0.118120E-00
147	0.111649E 03	0.134360E 03	-0.203405E-00
148	0.854332E 02	0.967563E 02	-0.132537E-00
149	0.465279E 02	0.662864E 02	-0.424657E-00
150	0.387449E 02	0.460725E 02	-0.189125E-00
151	0.331317E 02	0.362614E 02	-0.944626E-01
152	0.298903E 02	0.294685E 02	0.141119E-01
153	0.257953E 02	0.250119E 02	0.303692E-01
154	0.219394E 02	0.214151E 02	0.238955E-01
155	0.218585E 02	0.186530E 02	0.146649E-00
156	0.173332E 02	0.171444E 02	0.108926E-01
157	0.197915E 02	0.171223E 02	0.134870E-00
158	0.166690E 02	0.178605E 02	-0.714824E-01
159	0.136681E 02	0.174668E 02	-0.277926E-00
160	0.163158E 02	0.176656E 02	-0.827302E-01
161	0.211793E 02	0.190919E 02	0.985585E-01
162	0.145080E 02	0.159963E 02	-0.102586E-00
163	0.127206E 02	0.171594E 02	-0.348948E-00
164	0.185922E 02	0.167506E 02	0.990489E-01
165	0.129066E 02	0.176014E 02	-0.363753E-00
166	0.159526E 02	0.169053E 02	-0.597226E-01
167	0.103623E 02	0.155604E 02	-0.501630E 00
168	0.938966E 01	0.161008E 02	-0.714734E 00
169	0.116285E 02	0.137344E 02	-0.181100E-00
170	0.116400E 02	0.125562E 02	-0.787146E-01
171	0.125869E 02	0.114604E 02	0.895012E-01
172	0.554314E 01	0.103053E 02	-0.859109E 00
173	0.237525E 01	0.942041E 01	-0.296607E 01
174	0.113635E 02	0.925970E 01	0.185133E-00
175	0.115064E 02	0.911306E 01	0.208004E-00
176	0.105104E 02	0.748590E 01	0.287761E-00
177	0.607622E 01	0.555944E 01	0.850502E-01
178	0.905896E 01	0.538467E 01	0.405598E-00
179	0.738457E 01	0.521593E 01	0.293672E-00
180	0.734953E 01	0.429387E 01	0.415762E-00
181	0.541218E 01	0.615505E 01	-0.137260E-00
182	0.310926E 01	0.557551E 01	-0.793196E 00
183	0.547192E 01	0.458817E 01	0.161507E-00
184	0.759416E 01	0.524706E 01	0.309066E-00
185	0.118549E 02	0.747385E 01	0.369556E-00
186	0.131472E 02	0.956C02E 01	0.272850E-00
187	0.944397E 01	0.12.906E 02	-0.290833E-00
188	0.168582E 02	0.172127E 02	-0.210236E-01
189	0.251928E 02	0.209933E 02	0.166695E-00
190	0.251241E 02	0.247628E 02	0.143800E-01
191	0.358085E 02	0.305171E 02	0.147768E-00
192	0.373595E 02	0.335615E 02	0.101661E-00
193	0.329956E 02	0.357562E 02	-0.836649E-01

194	0.330578E 02	0.356145E 02	-0.773405E-01
195	0.300821E 02	0.312755E 02	-0.396704E-01
196	0.200154E 02	0.294474E 02	-0.471238E-00
197	0.190979E 02	0.218289E 02	-0.143005E-00
198	0.205788E 02	0.182442E 02	0.113449E-00
199	0.103583E 02	0.139312E 02	-0.344933E-00
200	0.648022E 01	0.112263E 02	-0.732402E 00
201	0.547805E 01	0.757228E 01	-0.382295E-00
202	0.578575E 01	0.552227E 01	0.455387E-01
203	0.601810E 01	0.455502E 01	0.243113E-00
204	0.215728E 01	0.338789E 01	-0.570447E 00
205	0.232621E 01	0.220369E 01	0.526707E-01
206	0.730760E 00	0.134290E 01	-0.837679E 00
207	0.140036E 01	0.440938E-00	0.685124E 00
208	0.114356E 01	0.411810E-01	0.963989E 00
209	0.108040E 01	-0.	0.100000E 01
210	0.845301E 00	-0.	0.100000E 01
211	0.165598E-01	-0.	0.100000E 01
212	0.232324E 01	-0.	0.100000E 01
213	0.225896E 01	-0.	0.100000E 01
214	0.150792E 01	-0.	0.100000E 01
215	0.758265E 00	-0.	0.100000E 01
216	-0.915475E 00	-0.	0.100000E 01
217	-0.250783E-00	-0.	0.100000E 01
218	-0.253987E-00	-0.	0.100000E 01
219	0.389618E-01	-0.	0.100000E 01
220	0.149993E 01	-0.	0.100000E 01
221	0.137151E 01	-0.	0.100000E 01
222	-0.346253E-00	-0.	0.100000E 01
223	-0.935629E 00	-0.	0.100000E 01
224	0.254949E-00	-0.	0.100000E 01
225	0.444292E-00	-0.	0.100000E 01
226	0.621502E 00	-0.	0.100000E 01
227	0.279280E-00	-0.	0.100000E 01
228	-0.546097E 00	-0.	0.100000E 01
229	0.104254E-00	-0.	0.100000E 01
230	-0.346501E-00	-0.	0.100000E 01
231	0.792332E 00	-0.	0.100000E 01
232	0.688880E 00	-0.	0.100000E 01
233	0.143204E 01	-0.	0.100000E 01
234	-0.379016E-00	-0.	0.100000E 01
235	-0.520248E 00	-0.	0.100000E 01
236	-0.391187E-00	-0.	0.100000E 01
237	-0.174698E-02	-0.	0.100000E 01
238	0.308230E-00	-0.	0.100000E 01
239	-0.662825E 00	-0.	0.100000E 01
240	0.560263E 00	-0.	0.100000E 01
241	0.404700E-00	-0.	0.100000E 01
242	-0.775653E 00	-0.	0.100000E 01
243	0.674883E 00	-0.	0.100000E 01
244	0.471434E-00	-0.	0.100000E 01
245	-0.490600E-01	-0.	0.100000E 01
246	-0.101594E-00	-0.	0.100000E 01
247	0.598437E 00	-0.	0.100000E 01
248	0.100919E 01	-0.	0.100000E 01
249	0.166220E 01	-0.	0.100000E 01
250	0.178659E-00	-0.	0.100000E 01
251	-0.900828E 00	-0.	0.100000E 01
252	0.383659E-00	-0.	0.100000E 01
253	-0.167837E-00	-0.	0.100000E 01
254	-0.791284E 00	-0.	0.100000E 01

ZERO DRIFT OF -0.04883 GIVES CHI SQUARE VALUE 0.245477E 01

CORRELATION MATRIX STANDARD DEVIATION = DIAGONAL ELEMENT X SQUARE ROOT OF CHI SQUARE VALUE
OFF DIAGONAL ELEMENT = CROSS CORRELATION

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ROW   1
    0.63151E-03
ROW   2
    0.69617E-01     0.26015E-02
ROW   3
    0.45793E-02     0.14011E-02     0.15143E-02
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